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HERB. I. M. I. HANDBOOK

Methods in use at the

Commonwealth Mycological Institute

Commonwealth Mycological Institute
Ferry Lane, Kew, Surrey
1960

Price 12s. 6d.

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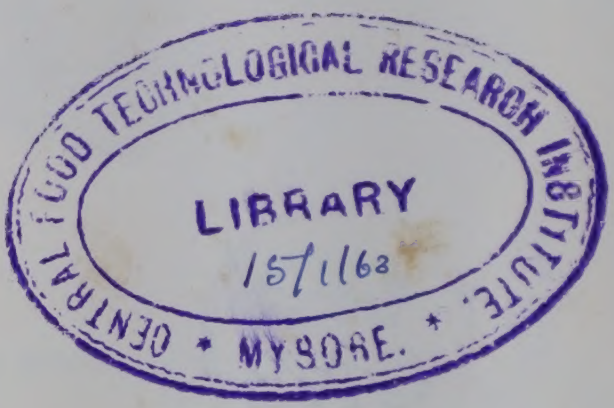

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To

EDMUND WILLIAM MASON

O.B.E., M.A., M.Sc.

This book endeavours to indicate not only the practices and techniques employed at the C.M.I. but also the principles followed. It should be clear that the Herbarium—Herb. I.M.I. —is the focal point of all activities. The conception is essentially holistic : even the newcomer Bacteriology and the industrial side of the Culture Collection fit naturally into the framework built around the Herbarium. Plant pathology is a rapidly expanding science with biochemistry exerting an ever increasing influence on research. So much so that doubts are to-day expressed regarding the value of systematic mycology in this field. Some go so far as to say that a mycological training is no longer necessary for a plant pathologist providing he has a sufficient knowledge of botany to understand plant physiology.

Admittedly, the biochemistry of host-pathogen relations is still little understood and new avenues of research are opened up by the vast improvements in biochemical techniques which have been developed in recent years, but it is still necessary, and always will be, for the research worker to be able to recognize his fungus whenever he encounters it. Only a sound knowledge of mycology can ensure this. It does not always happen, and many wrong conclusions have been arrived at due to faulty diagnosis. Only recently there has been the case of *Helminthosporium sativum* on the roots, leaves, and seeds of a grass. Examination in Herb. I.M.I. has shown that three species of *Helminthosporium* were involved, none of which was *H. sativum*. Such instances are not rare.

Erroneous identification can, of course, be corrected by the systematist, but it is impracticable for the research worker to submit every specimen to the systematist. Ability to recognize a species a second, and, indeed, every time is a basic duty of all pathologists.

It is the realization by the staff of C.M.I. of what fundamental asistance Mason has given to simplifying the task of identification of micro-fungi that has prompted them to dedicate this book in appreciation of his services to mycology.

5 April, 1960

J. C. F. Hopkins

Director

CONTENTS

Page

Foreword ..... J. C. F. Hopkins

Introduction.

The Commonwealth Mycological Institute.....S. P. Wiltshire 1

The Herbarium.....M. B. Ellis 24

How to describe a fungus.....F. C. Deighton 37

Laboratory methods used in the Culture Collection .....H. A. Dade 40

The treatment of important pathogenic Phycomycetes.....Grace M. Waterhouse 70

Bacteria and the Herbarium.....A. C. Hayward 73

Collecting fungi.....C. Booth 76

Collecting in the tropics.....F. C. Deighton 78

Collecting in the clinic.....G. C. Ainsworth 83

The *Index of Fungi*.....F. C. Deighton 85

The *Bibliography of Systematic Mycology*
Grace M. Waterhouse 89

The Herbarium and the *Review of Applied Mycology* .. ..E. B. Martyn 91

The *Review of Medical and Veterinary Mycology* and the Herbarium .....G. C. Ainsworth 93

List of Staff, 1st April, 1960..... 95

List of Publications..... 97

THE COMMONWEALTH MYCOLOGICAL INSTITUTE

S. P. Wiltshire

The movement which led to the establishment of the Imperial Bureau of Mycology—later to be renamed the Imperial Mycological Institute and still later the Commonwealth Mycological Institute—originated from several sources. The remarkable success of the Imperial Bureau of Entomology, established in 1913 to encourage and co-ordinate entomological work throughout the Empire in relation to agriculture, was felt to justify the establishment of a similar Bureau dealing with the other great class of destructive agencies, the diseases of crop plants. With the outbreak of the 1914–18 war the shortage of supplies experienced emphasized the importance of conserving foodstuffs and other products of the vegetable kingdom, for the provision of which the home country is so dependent upon the agricultural prosperity of the overseas countries of the Commonwealth. In 1916, at the Newcastle meeting of the British Association specific proposals were made for the establishment of an Imperial Bureau of Mycology as a co-ordinating agency for helping in the study of the diseases of plants. At the same time the movement from within met with a similar movement from outside and some of the overseas workers began to press for better facilities in England to replace the help hitherto obtained from foreign sources.

The proposal to establish a bureau of mycology in London was laid before the Imperial War Conference in 1918, and backed by the support of that powerful body was referred to the Overseas governments for consideration. More than forty of these approved and undertook to finance the bureau for a period of three years in the first instance. On the initiative of the Colonial Office a Managing Committee was formed comprising a number of well-known botanists with Viscount Harcourt as Chairman. The appointment of Director of the Imperial Bureau of Mycology was accepted by Dr. E. J. Butler, later Sir Edwin Butler, Imperial Mycologist of India, who returned to England, and in September 1920 commenced work in the quarters of the former Plant Pests Branch of the Ministry of Agriculture and Fisheries at 17–19 Kew Green. The premises,

adorned with most beautiful ornamental ceilings, were originally two houses of the ladies in waiting of Queen Caroline and became vacant on the removal of the Plant Pests Branch to Harpenden. They provided convenient accommodation for the new Bureau, being near to the excellent library and herbarium of the Royal Botanic Gardens with whom it worked in close co-operation. After consultation with mycologists and plant pathologists both here and overseas it was agreed that the two main objectives of the Bureau should be the accummulation and distribution of information on all matters concerning the diseases of plants, and the identification of fungi injurious to overseas crops. Both these objectives were regarded as equally important and both have been followed consistently ever since, though various subsidiary activities have been developed in the course of years as will be seen.

The Review of Applied Mycology

The world's literature on plant diseases at that time was diffused in some 500 journals, annual reports, bulletins, pamphlets, books, and papers, and though the bulk of this literature was found to be available in the libraries at Kew and in London some 150 publications were not traced there. The research worker requires to know what is being done in his subject in all parts of the world and he wants the information in a readily available form. It was therefore desirable to start an abstracting journal, on the lines of the *Review of Applied Entomology*, abstracting the world literature on plant pathology and mycology. Owing to the comparatively small number of people to whom such a journal would appeal it could only be issued at a loss, but the funds needed for the project were forthcoming and the organization and publication of the *Review of Applied Mycology* were undertaken.

The bulk of the literature was coming from the United States, and before starting the new journal the Director paid a visit to that country to represent the British Government at a Conference on the diseases of cereals held by the American Phytopathological Society. Before and after the Conference, by visiting institutions and meeting the leading American phytopathologists he secured valuable co-operation and help from workers in the United States, and also in Canada.

Returning to Kew, he collected the staff necessary for running the new journal. In December 1920, Miss K. Secker was appointed abstractor for the Scandinavian, Dutch, German,

Sir Edwin Butler, C.M.G., C.I.E., LL.D., M.R., B.A.O., D.Sc., F.R.S.
— The first Director

and Italian publications. Dr. G. R. Bisby joined the staff as Assistant (Publications) in October 1921, but decided to return to Canada in 1922 when he was replaced by Mr. S. P. Wiltshire. Abstractors for the Slavonic and Spanish languages were also appointed, two clerical assistants and a laboratory attendant completing the personnel. With this small staff the Director succeeded in producing the first number of the *Review of Applied Mycology* in January 1922. It was an immediate success. The distinguished plant pathologist, Erwin F. Smith wrote, " You certainly deserve the congratulations and good wishes of every plant pathologist in the world." Appreciation of the new journal was general and the circulation rapidly increased.

The work of assembling and editing the *Review* was a first call on the Director. From the beginning his aim was to give sufficient information for workers to carry on research for the time being without consulting the original paper and to present a comprehensive survey of current literature with special reference to tropical crops. The index of the first volume was issued in April 1923, and from the start considerable importance has been attached to having an adequate index for the *Review*.

To compile the *Review*, essential periodicals had to be regularly scanned, and here the assistance of the well-established library of the Royal Botanic Gardens proved invaluable. Unavailable literature had to be obtained by subscription, but a ready response to appeals made to plant pathologists and mycologists to send separates of their papers for filing and for lending purposes overcame some of the major difficulties. In this way a library of separates was initiated which has been built up over the years into a very valuable collection. The number of separates in the collection in 1959 amounted to about 80,000. To-day much of the literature required for abstracting is obtained by a system of loans.

In 1923, the Director was one of the four delegates of the British Government to the Pan-Pacific Science Congress held in Australia in July and August. This tour was extended to include Canada, Hawaii, Fiji, and New Zealand. It was as successful as his tour to the United States and did much to establish those cordial relations with workers in the Commonwealth that have been maintained ever since.

Identification Service

The other main line of work of the Bureau, the identification of fungi injurious to overseas crops, was commenced at the same

time as the *Review* was started. E. W. Mason was appointed assistant mycologist (systematic) in 1921 and the task before him was indeed a difficult one. At that time there were very few professional systematic mycologists in Great Britain, and the state of mycology was comparable to that of chemistry about the middle of the last century. To ascertain the correct name of a pathogen meant hunting through a mass of undocumented papers and comparing the specimens received with those preserved in herbaria, particularly those in the herbaria of Kew and the British Museum (Natural History), through the kindness of Directors of those Institutions. The time taken for an identification varied from five minutes if well known to five years or longer. The specimens from overseas for critical examination began to arrive immediately and in the first six months parcels were received from Australia, India, Egypt, the Sudan, Uganda, Kenya, the Gold Coast, Nigeria, the Belgian Congo, Palestine, the Strait Settlements, and Fiji.

Among the more interesting specimens were the omnivorous parasite *Sclerotium rolfsii* from India (the only previous eastern records being from the Dutch East Indies, Japan, and the Philippines) and the destructive blast disease of rice in Uganda, the first African record. Specimens from India of the newly discovered linseed wilt was determined to be the same as that of the destructive flax wilt of America. The foot rot and scab fungus on temperate cereals was discovered on rice from Uganda. The identification work continued to increase at a rapid rate affording ample proof of the urgent need for the service, and new records were frequently made, a number of them of major pathological importance : *Xanthomonas malvacearum* on cotton from the Sudan and Uganda, pink disease (*Corticium salmonicolor*) on coffee from Kenya, and Panama disease of bananas (*Fusarium oxysporum* f. *cubense*) from the Canaries and from Sierra Leone (the first record from the mainland of Africa), and so on. This help to pathologists of overseas territories was greatly appreciated and stimulated further reaserch on their part.

The first Imperial Mycological Conference

In 1924, the first Imperial Mycological Conference was held in London. Australia, New Zealand, South Africa, Irish Free State, India, and twelve Colonial Dependencies, as well as the Imperial College of Tropical Agriculture, Trinidad, sent

representatives. In addition, there were a number of mycologists from the home government and research stations. Among the resolutions adopted was one recommending that the annual income of the Bureau be raised to £6,500 for the next five years, and another expressing the urgent need for increased accommodation. The Conference also recommended that lists of determinations of fungi received at the Bureau should be published, and that a list of names and addresses of all mycologists and plant pathologists in the Empire be published. The first address list appeared in 1925, there being 282 ; of these 117 were in Great Britain and 52 in Canada.

In May 1926, Professor S. F. Ashby from the Imperial College of Tropical Agriculture, Trinidad, joined the staff as mycologist. As the identification work was rapidly increasing the appointment was greatly welcomed. His wide experience and thoroughness made him a most valuable addition to the staff, and much increased the competence and speed of the Bureau in dealing with enquiries, especially from the tropics.

Until 1926, no provision had been made for pensions for the staff on retirement, but in that year the Bureau was admitted to the Federated Superannuation Scheme for Universities.

In August 1926, the Director attended the International Congress of Plant Science at Ithaca, New York, where he was chairman of the Section of Mycology. He made further acquaintance with mycologists from various parts of the world, and did much to establish the work of the Bureau on a definite international plane.

The new building of 1930

In 1926, the need for increased accommodation became so urgent that the Director was instructed to take up the matter seriously. The Director of the Royal Botanic Gardens, Kew, offered a suitable site near the Harbarium and Library buildings, within the boundaries of the Gardens. At a special meeting of the Managing Committee in July 1927 it was decided to approach the Empire Marketing Board, who eventually made a grant of £8,000 towards the cost of the proposed new building, the balance of the total cost, £12,000, being provided from the reserve fund of the Bureau.

Plans were prepared by H.M. Office of Works, the architect being Mr. J. H. Markham, F.R.I.B.A., and the lease granted to the Director and Assistant Director by name in virtue of the posts held by them and to their successors in these posts, as from

25th March, 1929. The building was commenced during the summer, the walls reaching four feet high at the time of the visit of the Second Imperial Mycological Conference in September, and occupied towards the end of July 1930. It proved convenient, efficiently designed, and comfortable. The external appearance was dignified and in keeping with the older Georgian houses on Kew Green. The Office of Works had produced a good building and the money had been well spent.

The second Imperial Mycological Conference, London, 1929

This was widely representative and discussions lasted a full week. A resolution emphasizing the need for a series of handbooks on the diseases of tropical and sub-tropical crops was adopted and the importance of measures for the certification and quarantining of plant imports was stressed, the outbreak of witches' broom disease of cacao in Trinidad having focussed attention on this aspect of disease work. A form of certificate of inspection of plant shipments was drafted for submission to Governments. The question of seed-borne diseases called for increased attention throughout the Empire and the appointment of specialists to work with seed-testing stations was recommended. It was recommended that the income of the Bureau be increased by £1,200 a year and in addition, it was considered that the preparation of maps showing the world distribution of the more important plant diseases was of such value as to be worthy of an extra £300 a year required to finance it.

Before these recommendations could be put into effect the world financial stringency of 1931 caused drastic measures to reduce expenditure to be made immediately. Salaries were cut as in similar services, the budget much reduced and the price of the *Review* increased. Economics were not the whole story. Additional abstracting staff could not be appointed and the *Review* staff were faced with the onerous task of trying to cope with the increasing literature as best they could. The strain was great but ultimately the reduction in phytopathological and mycological publications consequent upon the world-wide depression eased the situation.

The Imperial Agricultural Bureaux

An event which was destined to affect the future of the Bureau to a marked degree was the Agricultural Research Conference of 1927. This Conference recommended the establishment of eight Imperial Bureaux as effective clearing houses for the exchange of information of value to research

workers in agricultural science, involving *inter alia* the publication of abstracting journals. These Bureaux were to be financed from a common fund contributed by Commonwealth governments in agreed proportions and controlled by a Council composed of representatives of those Governments on an equal footing. On 1st April, 1929, the Executive Council of the Imperial Agricultural Bureaux came into being.

With the establishment of the new Bureaux, dealing only with abstracting services, the question arose of distinguishing them from the Imperial Bureaux of Entomology and Mycology. which also provided identification services for plant pests and plant pathogens. The Honorary Committee of Management decided to rename these Bureaux the Imperial Institute of Entomology and the Imperial Mycological Institute as from 1st January, 1930.

As a result of the Imperial Conference at Ottawa in 1932 the Imperial Committee on Economic Consultation and Co-operation, under the chairmanship of Dr. O. P. Skelton, the Canadian Under-Secretary of State for External Affairs, was appointed by the Governments of the Empire to examine the organization and work of various inter-Imperial bodies. The Committee approved the work done by the two Institutes, but considered that their general control and administration would be better vested in the Imperial Agricultural Bureaux organization. This was approved by all Empire Governments and the transfer to the Executive Council of the Imperial Agricultural Bureaux of the two Institutes took effect from 1st October, 1933.

The third Imperial Mycological Conference, London, 1934

This was held under the chairmanship of Sir Charles Howell Thomas, K.C.B., K.C.M.G., chairman of the Executive Council of the Imperial Agricultural Bureaux, and discussed losses due to the destruction of crops by disease. It was estimated that in Germany cryptogamic diseases caused a loss of £80,000,000 a year, of which £18,000,000 were due to losses in the potato crop. Similarly, plant disease losses in Australia amounted to £7,000,000 in 1920, in Switzerland from £2,800,000 to £3,600,000 in 1927, in Holland £2,500,000 in the same year, in Ireland between the first report of potato blight and 1926, a period of eighty years, the loss from this disease alone was calculated about £200,000,000. New Zealand reckoned in 1927 that it lost half its potato crop from diseases other than the virus group. Biffen and Engledow wrote in 1926 that cereal rusts were costing

the world £100,000,000 a year. In comparison with these huge losses the Conference estimated that an annual expenditure necessary to put the Institute on a satisfactory financial basis during the ensuing five years would amount to £7,690.

The Conference dealt largely with the question of plant disease legislation and the dangers inherent in the rapidly developing air transport, and recommended a form of general health certificate for adoption in Empire countries, which by 1936 had been so widely adopted in the Empire as to be practically universal. The Conference also considered *inter alia* greater standardization of fungicides and the simplification of control measures for use by small cultivators.

A pleasing tribute to the work of the Institute was the presentation of an oak settle for the entrance of the new building by the American Phytopathological Society. The Imperial Chemical Industries Ltd., also, in recognition of the value of the work of the Institute, made a first grant of £100 per annum in 1934–5 and this has been continued to the present time.

In September 1935, Dr. E. J. Butler resigned from the office of Director to become the first full-time Secretary of the Agricultural Research Council. He was the first Director of the Institute and had been responsible for its formation and development during the sixteen years he had been Director. The loss to the Institute was incalculable. Mycologists and plant pathologists from all over the world had visited him at the Institute and found him ever ready to discuss their problems. To the Commonwealth he gave unstintingly of his learning and advice, and the regret at his resignation was universal. Of the many tributes to him that of W. L. Waterhouse of Sydney University on behalf of forty-six plant pathologists is worthy of record. It reads as follows, "Mycological workers in Australia heard of your resignation from the Directorship of the Imperial Mycological Institute with the deepest regret. In common with workers throughout the world, for many years we have been reaping the benefits of your outstanding ability, your wide experience, your generous assistance, your wise administration, and your wonderful devotion to duty. Your life and work have served to inspire many workers. Our hope is that your health has not been impaired by the heavy demands made upon you." A clock made of Australian woods accompanied this message.

S. F. Ashby, the senior Mycologist at the Institute was

appointed to succeed Dr. Butler as Director. In the consequential appointments, the Assistant Mycologist, E. W. Mason, was appointed Mycologist, the Assistant Director, Dr. Wiltshire, took over the editing of the *Review of Applied Mycology*, and the Mycologist of the Gold Coast, H. A. Dade joined the staff as Assistant Mycologist and sub-Editor.

In Mr. Ashby's first report he stressed the importance of taxonomic investigation as a preliminary to identification in very many of the more obscure genera and species, and the need for systematic study of plant pathogens before they could be correctly identified. This work had been carried out in close co-operation with mycologists in the overseas part of the Empire and from the start the identification service proved of great value to plant pathologists.

Handbooks

At the Second Imperial Mycological Conference, 1929, it was recommended that a series of handbooks dealing with the diseases of the most important tropical crops be undertaken, and in 1934 by Professor H. R. Briton-Jones, published 'The diseases and curing of Cacao'. In the following year Dr. C. W. Wardlaw issued a comprehensive work 'The diseases of the banana and of the Manila hemp plant'. The author was able to acknowledge the help given by the Institute in the identification of pathogenic fungi and in the bibliography. Mr. Sharples, for many years mycologist in Malaya, used the Institute and its resources in preparation of his well known book 'The diseases and pests of the Rubber Tree', published in 1936.

Banana species collected overseas for breeding work at Trinidad were quarantined in a special glasshouse at the Royal Botanic Gardens, Kew. Mr. Ashby inspected these from time to time, and also cacao plants raised from seed at the Gardens for West African Colonies.

The need for additional help in the identification service was stressed by the Conference of 1929 and 1934, and Dr. G. R. Bisby rejoined the staff on the completion of his service as Professor of Plant Pathology in the University of Manitoba. Mr. Mason was thereby free to devote his attention to the third fascicle of the 'Annotated Account of Fungi received at the Imperial Mycological Institute—general part', which was published in September 1937. In this part, which will come to be regarded as a milestone in systematic mycology, he advocated a more correct method of classifying and naming Fungi Imperfecti

and one better suited to the need of applied mycology.

During May to July 1937, Mr. Dade visited the Gold Coast to investigate and advise upon a swollen shoot and die-back of cacao. He came to the conclusion that the cause was largely physiological due to poor conditions of culture, but suggested that a virus might be involved and tested for. His conclusions are now receiving support from the most recent research carried out in Ghana.

The outbreak of war completely disrupted the plans for the Fourth Imperial Mycological Conference timed for September 1939. The Conference had to be cancelled and none could be held during the period of hostilities.

In December 1939, Mr. S. F. Ashby retired from the post of Director. His overseas experience and his wide and sound views on pathological problems were greatly missed at the Institute. Moreover, he was an acknowledged authority on the Phycomycetes, fungi of great pathological importance, and he had been able to devote much of his time to research on the group, besides providing identifications for many overseas pathologists. With the uncertain state of systematic mycology it is difficult to hand on knowledge from one generation to the next, and the retirement of Mr. Ashby left a gap in the range of fungi covered by the Institute that was not filled until the appointment in 1946 of Miss Waterhouse, also an authority on Phycomycetes. Dr. S. P. Wiltshire, the Assistant Director, was appointed to succeed Mr. Ashby. He retained the editorship of the *Review*, and Mr. H. A. Dade became Assistant Director and Sub-Editor. Dr. G. C. Ainsworth joined the staff as Assistant Mycologist in June 1939.

An important advance in the standardization of names of plant pathogenic fungi was achieved in 1939, largely due to the initiative of Mr. Mason, who succeeded in bringing about the adoption of the British Mycological Society's 'List of Common names of British Plant Diseases' as standard by forty-two offices, societies, and institutes in the British Isles.

The outbreak of war caused less dislocation of our work than might have been expected. Incoming literature was reduced, chiefly from the countries in enemy occupation, and the number of specimens and cultures received also diminished, from about 500 to 280 in 1940–1. Nevertheless the work of the Institute was carried on and very good use was made of the breathing space to revise certain parts of the organization, among which

was numbering and indexing the specimens in the Herbarium which was completed in 1950, and a complete index of all specimens under the host and fungus names is now maintained as part of the Herbarium routine.

Distribution Maps of Plant Diseases

As the war progressed the abstractors, of which there were only three (the minimum needed to cover the languages used), found difficulty in obtaining literature to abstract, a state of affairs not known before or since. The Second Imperial Mycological Conference recommended that full information in regard to the diseases of crop plants throughout the world should be compiled in a form readily accessible in order to facilitate protective legislation and to further knowledge of the means by which diseases are spread from one country to another. With the help of abstractors an opportunity was afforded of carrying out this work and from March 1942, two maps, each showing the distribution of a pathogen, have been published by the Institute each month. The work of bringing maps up to date is considerable but the publication has been maintained. A total of 370 maps had been issued up to 1st January, 1960.

Supplements to the Review

After the 1914–18 war the lack of information about new species of fungi was very painfully felt. Hours of time were absorbed in searching for the original descriptions of fungi that might perhaps be the same as those under study. To reduce this labour it was decided to issue *Supplements* to the *Review* listing all new genera, species, and varieties of fungi noticed in the literature published since the beginning of 1940, with complete references to the publications in which the original description appeared.

The Hankey Committee and medical mycology

In view of the impracticability of holding any Conferences during the war the Executive Council of the Commonwealth Agricultural Bureaux obtained the services of a number of distinguished scientists in Britain under the Chairmanship of Lord Hankey to review the work of the Institutes and Bureaux. The Committee assembled on 10th November, 1942 and held fifteen meetings. Its report was published in 1943.

The *Review of Applied Mycology* had noticed papers on medical mycology from the beginning, for Dr. Butler was a medical man by training though he never practised. The

literature on the subject was growing and a decision on policy was urgent. Dr. Wiltshire felt that the subject had either to be dropped or expanded to cover adequately the literature, which could only be done with the collaboration of medical workers. The abstracts in the *Review of Applied Mycology* were not read by many medical people and he suggested a separate abstracting journal appearing three times a year. Medical fungi needed the attention of systematic mycologists and without correct identification it would be difficult to make progress. Following a recommendation of the Hankey Committee the Medical Research Council appointed a committee of five to consider the provision of research in medical mycology. It unanimously recommended the formation of a research committee for the subject. The Medical Research Council thereupon appointed a larger committee of twelve to examine the situation further. This committee also recommended the more intensive study of the subject and stressed the need for better dissemination of information. A committee on research in medical mycology was thereupon appointed by the Medical Research Council, comprising both medical men and mycologists. For the first time, collaboration between both was secured.

In 1944, the Institute published with the co-operation of Dr. C. Wilcocks of the Bureau of Hygiene and Tropical Diseases and Dr. J. T. Duncan, an *Annotated Bibliography of Medical Mycology*, 1943, with references to abstracts in certain abstracting journals, occupying thirty-two pages, including an index. Later, the notes on the papers became much fuller and it was decided in 1951 to alter the title to the *Review of Medical and Veterinary Mycology*, appearing bi-annually. By 1952, the number of subscribers had increased to 213. The publication was continued under difficult circumstances for several years owing to lack of staff, but it gradually established itself and in 1958 became a quarterly of thirty-two pages per issue, not including index, in which form it is still appearing with the active assistance of the Bureau of Hygiene and Tropical Diseases and the Commonwealth Bureau of Animal Health. By 1959, the circulation had increased to 463.

Mycological Papers

From 1925 onwards Mr. Mason had published a series of valuable annotated accounts of fungi received at the Institute. This somewhat clumsy title was awkward to cite and called for a more convenient name. At the same time, difficulty was

experienced in obtaining publication of papers submitted to the Institute by overseas mycologists. Accordingly it was decided to adopt the name *Mycological Papers* for occasional mycological papers published by the Institute, in which Mason's series was included. Other papers followed and seventy-five *Mycological Papers* have been published up to March 1960.

The Dictionary of the Fungi

Drs. Bisby and Ainsworth collaborated after the war in compiling 'A Dictionary of the Fungi'. The aim was to provide mycologists with a handy book of reference to the genera of fungi, their systematic position, and the distribution and number of species. In addition, short accounts were given of the chief families, orders, and classes of fungi, explanation of words used in mycology, the common and scientific names of important fungi, and other details of interest to systematic and applied mycologists, and to plant pathologists. It was published in September 1943 and was an immediate success. In fact, the book turned out to be the Institute's best seller and the fifth edition will appear in 1960 as a companion to this volume. The text is regularly revised and kept up-to-date and its usefulness constantly maintained.

Imperial Agricultural Review Conference, September, 1946

Just one year after the close of the war, the first Imperial Agricultural Bureaux Review Conference since 1936 was held, and the second periodical examination made in accordance with the recommendation of the Imperial Committee on Economic Consultation and co-operation in 1933. The Conference reviewed the whole of the work of the Bureaux and Institutes, which became on 1st January, 1948, Commonwealth Agricultural Bureaux and Commonwealth Institutes. The Conference recommended that steps should be taken at an early date to double the accommodation of the Institute, but considerable difficulty presented itself in obtaining a site. The Director of the Royal Botanic Gardens could find no site on Kew Gardens land which did not interfere with the future expansion of the Kew Gardens Herbarium and Library building. An area across Ferry Lane was available but would involve buying old houses, involving an expenditure of £10,000, and even then it was doubtful if planning permission could be obtained for building. The matter remained undecided and in the Annual Report for 1947–48 the Director said that lack of accommodation was definitely impeding the work of the Institute.

The Culture Collection

In 1947, an important expansion of the Herbarium took place with the commencement of a culture collection of fungi of interest to the Institute. The need for such a collection had long been felt by Mr. Mason, but no opportunity of starting one had presented itself. As far as possible the cultures were backed by herbarium specimens from which the isolation was made and the cultures were given the same numbers as the herbarium specimen. It was intended that the collection should be built up very gradually, but the decision of the Lister Institute to discontinue the maintenance and distribution of fungus cultures necessitated the Institute taking over the National Collection of Type Cultures without delay ; but only undertaking at first to care for those of phytopathogenic interest. At this juncture a Specialist Conference on Culture Collections of Micro-organisms was held in London in August 1947, and this Conference recommended that " in the United Kingdom. . . . the Imperial Mycological Institute should be responsible for cultures of fungi other than medical fungi and yeasts." It was understood that timber-rotting fungi should still be maintained at the Forest Products Research Laboratory, Princes Risborough. It was emphasized that this heavy additional work could not be carried out without additional staff and apparatus.

Mr. Dade commenced the work of establishing the collection with the sole help of a junior laboratory assistant and encountered great difficulties. For instance, delay in obtaining a refrigerator was responsible for a severe mite infestation, which greatly impeded the work, until a refrigerator was obtained and the outbreak overcome. Before incorporating the National Collection in the Institute Collection every culture was examined and checked as opportunity offered. At the end of the year 1947–8 some 450 isolations were in maintenance and about 500 cultures from the Lister Institute in cold storage. Distribution of cultures began in June 1947. Two hundred and three cultures were supplied for payment, and fifty free of charge to Ministry of Agriculture workers and collaborating mycologists. The work was hampered by lack of accommodation and lack of staff, but progress was made in spite of all difficulties. The number of cultures maintained in the Collection increased from 724 in 1948 to 2,700 at the end of 1959, and the cultures per annum issued to clients from 604 to 1,670. Industry made good use of the collection, 763 industrial cultures being issued in

1958 ; research workers and educational establishments in that year took 482, and 156 were issued free either in exchange or to official workers on the free list.

The Fourth Commonwealth Mycological Conference, July, 1948

Fourteen years had passed since the last conference and there was much to discuss. Plant disease legislation was much to the fore and the conference supported the proposal for an African Phytosanitary Convention for all territories south of the Sahara and made various recommendations relating thereto. Valuable discussions took place on seed certification against seed-borne diseases, the control of virus diseases and of cacao swollen shoot in particular, the virus diseases of fruit in Canada, the control of phloem necrosis of tea in Ceylon, the tomato spotted wilt virus, the control of virus diseases by certification of vegetatively reproduced crops, the control of potato viruses by certification, and virus problems in the certification of fruit and hops. Other subjects that came before the conference were the diagnosis of nutritional disorders, the losses due to fungi in stored food-stuffs, the biological control of insects and weeds, forest pathology, the certification of fungicides, the use of fungicides in the control of tropical plant diseases, the development of new fungicides, and, in a joint meeting with the Commonwealth Entomological Conference, recent developments in pest and disease control machinery and the application of insecticides and fungicides from the air—a very comprehensive programme.

The conference viewed with much concern the inadequate accommodation provided at the Institute and recommended that the requirements of buildings and staff should be brought to the notice of the Review Conference of 1950.

The new building of 1955

In 1949, the Executive Council decided to purchase the adjacent properties 59, 61, and 63 Kew Green as a site for the erection of a new building as envisaged by the Imperial Agricultural Bureaux Conference of 1946 for the sum of £11,000.

It was with immense relief the staff received the news. The Institute was happy to secure the services of the distinguished architects Messrs. Waterhouse and Ripley, P.F.R.I.B.A., who prepared draft plans at short notice in time for circulation to the delegates of the Commonwealth Agricultural Bureaux Review Conference, 1950.

The purchase of the property eliminated the necessity of

providing temporary accommodation at great expense and labour and moreover, four rooms previously used for a restaurant were available almost immediately. The additional accommodation was invaluable to the Institute. The sales of publications had increased sixfold in the last ten years and without it the publications section would have become disorganized. The removal of the Sub-Editor and abstracting staff from the old building to 61 Kew Green made more room for visitors who wished to work at the Institute, though even then, some preferred to go elsewhere when they saw the accommodation offered.

The Commonwealth Agricultural Bureaux Review Conference, 1950, visited the Institute in July and were able to see the crowded conditions of work. The conference recommended to governments the draft plans which had been so expeditiously prepared by the architects for the new building. Even so, the proposal had to be submitted to governments and it was not until 25th March, 1954 that the project was finally agreed to. The contract was placed in April 1954, and the new building started in September. By the end of the year the main structure was nearing completion. It was opened by H.R.H. the Duke of Edinburgh on 13th July, 1955. The Chairman of the Executive Council of the Commonwealth Agricultural Bureaux, Mr. W. F. C. Morton, of South Africa, welcomed His Royal Highness and presented to him a number of distinguished visitors. The opening ceremony was performed in the large room destined for the future library, and after a speech by the Chairman, His Royal Highness spoke and unveiled a bronze plaque commemorating the event. He then toured the building and showed keen interest in the work of the staff.

The accommodation provided in the new building made a vast improvement in the working conditions of the Institute. The ground floor was devoted to the library, the second floor to the Herbarium, the top floor to visitors rooms and the Culture Collection, and the basement to a publications store, photographic rooms, a workshop, and the boiler room.

The flooding of the publications store

Before the new building was erected, however, a disaster occurred to the publications section in 63 Kew Green. As soon as the premises had been acquired the large ground floor room of No. 63 with the corresponding large cellar beneath were immediately allocated to publications and many weeks were

The Commonwealth Mycological Institute

spent in transferring to the cellar stocks of books from the low pitched, underground cellars below the Kew Herbarium (where we had been allowed to keep them) and from all sorts of odd corners made use of for the purpose. For the first time, the stock was in something like order, and the volumes, tied together in parcels, were placed on racks made from old, war-time shelter beds, slightly modified. The satisfaction of the staff was great and a period of orderly progress was envisaged for some time to come. But it was not to be.

The great tempest, which did such great damage on the east coast of England and in Holland affected the Thames area also. It caused a tidal wave to sweep up the river and overflow the river bank on the night of the 31st January, 1953. The water rushed up the garden and overflowed on to Kew Green, meeting another torrent from the direction of Kew Bridge, and flooding the cellar at No. 63 within a few minutes. On the Monday morning following, the staff arrived to find the local fire brigade pumping water out of the cellar which had been flooded to within a foot or so of the ceiling. About three feet of water was still in the cellar and it was a sorry sight to see the book racks lying in all directions and the sodden books in complete disorder. As soon as possible salvage operations commenced. Wellington boots were procured and volunteers, chiefly from the office staff, formed a line and handed the books from one to another until they were ultimately deposited on the pavement outside to be taken the next morning to the Oxford University Press, who had kindly offered to dry them in their paper warehouse. A second load followed the next day. In due course we received the books back, dried, and salvaged, but there were great losses. All the stocks of bound books were ruined and reprinting many parts of the *Review* was essential.

The difficulties confronting the Publications section were intense. Two volumes of the *Review* were reprinted by H.M. Stationery Office but the cost was too high for our purse. A considerable number of orders for back issues of the *Review* had to be refused as there was no stock. The situation was desperate, for without publications to sell, an important part of our income was threatened. The only thing to do was to try and reproduce the missing parts ourselves by office printing methods. The essential equipment was within the resources of the Institute, but it was necessary to be as sure as we could of success before embarking on such an enterprise. To tell the

whole story would take too long, but before the new building started we were producing copies of the *Review of Applied Mycology* which had been out of print for years.

When the new building became available space was found in the basement for a first class camera room and a developing room. Finally, we succeeded for short periods in having complete sets of the *Review* for sale, though they sold so fast that it was difficult to maintain the sets in print. The flood turned out to be a blessing in disguise, for it provided the C.M.I. with a small photo-offset plant which not only continues to reprint out of print volumes, but affords facilities for the production of leaflets, price lists, advertisements, and many other kinds of small printing jobs at very short notice.

Commonwealth Phytopathological News

In January 1955, a development of some importance took place in the issue of a news sheet for plant pathologists under the name of *Commonwealth Phytopathological News*. As long ago as 1948, the Fourth Commonwealth Mycological Conference recommended the issue of such a publication but it had not been feasible to undertake it before. It provides a means for keeping plant pathologists and agricultural staffs informed of what is going on and it was hoped it would be a popular means of bringing the results of research into practice. Reproduced quarterly by lithography from copy typed at the Institute on an electric typewriter the publication was priced at 5*s*. per annum. There is no doubt it serves a useful purpose, but sales have been very disappointing and more personal subscribers are required to make the journal self-supporting. Subscribers in 1956 numbered 402, and 416 in 1959, mainly libraries. There is little doubt that *C.P. News* is read by at least five times this number.

Handbooks

Following out the recommendations of various Commonwealth Mycological Conferences the Institute has endeavoured to forward in any way it could the preparation of handbooks of interest to plant pathologists and mycologists. Besides those already mentioned on p.9 the Institute has published the following works.

'A manual of rice diseases' by G. Watts Padwick published in 1950. This book brought together information concerning the diseases of rice throughout the world, much of it obtained from very scattered sources. The latter part of the book dealt with all fungi recorded on rice and constitutes a

useful source of reference for plant pathologists.

' British smut fungi ' by G. C. Ainsworth and Kathleen Sampson was also published in 1950. This monograph presents a new systematic treatment of the smuts of Britain and a general account of this group of fungi. All British collections were examined, public records scrutinized, and descriptions based on British material prepared. The last English book on the smuts was Plowright's monograph published in 1889. The book is useful to students and research workers interested in this important group of plant pathogens.

' Leaf curl disease of cotton ' by S. A. J. Tarr was published in May 1951. The author gives a full and up-to-date survey of the literature on this disease.

' Ustilaginales of India ' by B. B. Mundkur and M. J. Thirumalachar appeared in February 1952. It gives an illustrated summary of all the smuts recorded from India. Smuts include some major parasites of crops plants and the book, therefore, has a special interest for plant pathologists.

' An introduction to the taxonomy and nomenclature of fungi ' by G. R. Bisby was published in November 1945. It was the first book of its kind and is invaluable to students and others interested in the systematics of fungi. The first edition of 1,500 was exhausted in November 1952 and a second edition was published in 1953.

' The fungi and plant diseases of the Sudan ' by S. A. J. Tarr appeared in 1955. It lists and annotates the fungi and plant diseases known to occur in the Sudan.

' Tobacco diseases, with special reference to Africa ' by J. C. F. Hopkins was published by the Institute in July 1956. Tobacco is an important crop in Africa and this new book met with a good reception.

Phytopathological Papers

The series of *Mycological Papers*, started in 1943 (see above, p.12) proved of great use to overseas mycologists as well as to ourselves. It was always intended that a complementary series of *Phytopathological Papers* should be issued but this was not possible until 1956 when the first paper of the series ' Losses caused by plant diseases in the Colonies ' by G. Watts Padwick was published. It proved popular and was soon followed by *Phytopathological Paper* No. 2, entitled ' Witches' broom disease of cacao ' by the late Professor R. E. D. Baker and P. Holliday in 1957. The disease is not known in Africa but is

rife in South America, not so very far away. Paper No. 3, entitled ' Club root disease of crucifers caused by *Plasmodiophora brassicae* Woron', by J. Colhoun was published in 1958. These three papers have given the series a good start and two others are in preparation in 1960.

The Herbarium

The work of the Herbarium has increased steadily from the start of the Institute. As already recorded the identification of fungi injurious to crop plants is one of the main functions of the Institute and many overseas plant pathologists have come to rely on this assistance. In the earlier references to it some account was given of the new records that occurred amongst the determinations made. To list all the records of major importance made or confirmed at the Institute would take too much space, but they are to be found in the annual reports of the Institute. The additional staff and new accommodation have played an important part in the development of the identification service, but the Herbarium owed much to Mr. E. W. Mason, the head mycologist, in organizing and superintending the work. For many years he has been the driving force behind it all. His approach to the taxonomy of fungi was modern and basing the determination on comparison with the type or " authentic " collections and fully appreciating the importance of culture work in elucidating the structure of fructifications he built up a valuable instrument for the identification of fungi. His views received wide recognition by mycologists throughout the world. The influence he unostentatiously exerted on the development of systematic mycology was far reaching. A separate account is given below of the details of the work of the Herbarium, the techniques adopted, the systematic library, the system of filing specimens and many other matters.

As Mr. Ashby pointed out in 1936 the identification of fungi involves a considerable amount of basic research and the results of these researches have been reported in papers by the staff from time to time. The Herbarium has paid attention to the Hyphomycetes, a group of great interest to the pathologist, but other groups have not been neglected. Mr. Mason has made a special study of the Pyrenomycetes, assisted by Dr. Booth in recent years; Mr. Mason, Dr. S. J. Hughes, and Dr. Ellis of the Hyphomycetes; Miss Waterhouse of the genus *Phytophthora* and allied genera; Mr. Dade of *Aspergillus*; the late Dr. G. R. Bisby and Mr. F. C. Deighton, the rusts. Occasionally visits

have been paid to continental herbaria to examine and study specimens of special interest to the Institute. This research work is the life blood of our identification service and is most fruitful in results.

An activity of the herbarium that has been followed as opportunity served is the despatch of named specimens to Commonwealth herbaria in exchange for material received. This work has been restricted, however, by the limited staff available.

The Index of Fungi

The listing of new species of fungi, first in the supplements to the *Review of Applied Mycology* and, since 1950, in the *Index of Fungi*, has been continued. In 1949, Professor Petrak visited the Institute and informed us that he had published during the war a list of new species for the years 1932–35 inclusive and had continued listing new species until 1943, by which time he had included all new species recorded down to 1938. He readily agreed to undertake the completion of his list from 1936–39. In addition, he made available his list for 1932–35 and this together with his other lists for 1920–31 have all been reprinted. The 1936–39 list was published by the Institute in 1950. A cumulative index for the whole of Petrak's lists for 1920–39 was completed and published by the Institute in 1956 (species index) and 1957 (host index), so that lists covering the years from Saccardo's *Sylloge fungorum* to date are now available.

A *Bibliography of Systematic Mycology* from 1943 onwards has been published annually, firstly in mimeographed form and later by photo-offset. Dr. G. R. Bisby was responsible for compiling the earlier issues, and since he retired Miss Waterhouse has undertaken the work.

Common names of virus diseases

In the *Review of Applied Mycology* great difficulty was experienced in determining names to adopt for plant viruses. It was decided finally to publish a list of common names of virus diseases and to specify the virus by adding the word virus to the common name. This avoided the difficulties of attempting the formulation of a scientific nomenclature for which no scientific basis existed. The first list prepared with the help of Dr. G. C. Ainsworth and others was issued as a mimeographed paper, later revised lists being printed as supplements to Vol. 24 (1945) and Vol. 35 (1957) of the *Review*.

The Pool of Plant Pathologists

In 1951, by arrangement with the Colonial Office under a scheme financed by the Colonial Development and Welfare Research funds, a Pool of Plant Pathologists was established at the Institute to investigate problems of major importance in Colonial territories where the requisite local staff was not available for such work. Mr. R. A. Altson, formerly senior plant pathologist to the Rubber Research Institute of Malaya, joined the Pool in November 1952. He left in January 1953 for Cyprus to investigate a disease of broad beans which had been causing a loss to the island of £10,000 per annum for several years. In 1954, he was able to establish the pathogenicity of *Fusarium oxysporum* and also its variety *redolens*, which was repeatedly isolated from diseased beans. The best way of controlling a soil-borne *Fusarium* is by resistant varieties and some North African seed obtained by Mr. Altson showed a degree of resistance in varietal tests. The seed was made available to the Cyprus Department of Agriculture whose responsibility it became to initiate breeding work to bring the initial research to a practical conclusion.

In December 1954, Dr. B. E. J. Wheeler was appointed to the Pool and left the same month for Nyasaland to investigate a leaf spotting of tobacco caused by *Alternaria longipes*, which was jeopardizing an extensive tobacco growing project of the Colonial Development Corporation. He was under the direction of Dr. J. C. F. Hopkins, who also visited the country and drew up a programme of investigation for Dr. Wheeler. The work was actively continued throughout 1954–5, and ultimately in 1956 Dr. Wheeler was able to present recommendations for control based on his work. No outbreak of the disease comparable to those of the first few years has occurred on the estates of the Colonial Development Corporation in Nyasaland where these recommendations were put into practice, and one obstacle to the expansion of flue-cured tobacco culture in Nyasaland was removed.

In May 1955, Mr. Altson left for Sarawak to investigate a serious disease of black pepper (*Piper nigrum*) estimated to be causing a loss of £100,000 per annum. It was suspected that a species of *Phytophthora* might be involved. Mr. Altson was joined in October by Mr. Holliday who was appointed to the Pool in September. Mr. Altson left Sarawak on leave in March. Mr. Holliday, in co-operation with Mr. Mowat of the Department

of Agriculture, established the identity of the pathogen as a species of *Phytophthora*, which Miss Waterhouse undertook to study. Mr. Holliday visited pepper growing areas in Indonesia and India in search for resistant varieties, and secured some types reputed to be resistant. These are now being tested in Sarawak for their resistance and it has already been shown that the Sarawak variety is a highly suspectible one.

Dr. Wheeler, in 1957, completed a preliminary survey of economic crop diseases in Malta, and is now in Zanzibar to investigate wither-tip of limes which is reputedly impeding the development of the lime juice and oil industry there. Preliminary success has been obtained with phenyl mercury eradicant sprays.

Overseas visits

From the commencement of the Institute visits overseas by various senior members have been made at the request of governments to advise on matters of plant pathology. Sir Edwin Butler visited the United States, Canada, Australia, and New Zealand in the early days, Nyasaland and other parts of Africa in 1927, and the Sudan and Palestine in 1931. Mr. Ashby the West Indies in 1929 and Mauritius in 1930, Dr. Wiltshire the West Indies, especially Dominica in 1924 and Singapore in 1949, Mr. Dade the Gold Coast in 1937, Dr. Hopkins Nyasaland in 1954, Nigeria and Malta in 1955, East Africa in 1957 and 1959, and Canada in 1959, besides the visits of the members of the Pool of Plant Pathologists already recorded.

Looking back over the years covered by this short history the change in world conditions stand out conspicuously as affecting the work of the Institute. In the early days, letters and specimens travelled by surface mail and if we sent a report, say, to Singapore, we never expected a reply in less than six weeks. Now it may come within a week. Air mail has speeded the tempo of our work enormously. Besides correspondence, incoming journals reach us much more quickly. All over the world the value of research is being appreciated and every country is giving increasing attention to the study of plant diseases. Knowledge is being increased faster than ever before and it becomes more and more difficult to cope with the ever growing literature.

But the necessity of abstracting and documenting this literature increases as its volume grows, and the Institute needs all the support it can get in its increasingly heavy task.

THE HERBARIUM

M. B. Ellis

The word " Herbarium " conjures up in the minds of many people a dry, uninteresting place where specimens are stored and only occasionally looked at—a sort of specialists' reference library where plants replace books. Herb. I.M.I. is very much like a reference library in some ways. Its specimens are fully catalogued and cross-indexed and are carefully kept and readily available at all times for reference ; it is also dry, but there the analogy ends. It is a busy place. Fresh and dried specimens and living cultures are being examined all the time and the unnamed ones received compared with correctly named ones in the folders. Life history studies are being carried out. Current literature is scanned, and specimens already laid away are constantly being redisposed to conform with modern research ; also when time permits taxonomic research is carried out by members of the staff and the results of their investigations are published in *Mycological Papers*. Other duties include the compilation of the very useful *Index of Fungi*. A duplicate collection provides specimens for exchange with other herbaria. Techniques employed in the herbarium are demonstrated to visiting mycologists and plant pathologists ; visits by students are encouraged and advice is given on problems of taxonomy and nomenclature.

SPECIMEN AND SPECIES

What is meant by a specimen ?

It is necessary to define at the outset what is meant by a specimen in mycological parlance. The term specimen is sometimes applied to a single fruit body of one of the larger fungi such as an agaric, but more often to one or more colonies of a micro-organism together with the substratum on which it occurs. The substratum may be a natural one, such as a leaf, or stem, or an insect ; it may be a manufactured product such as a piece of cloth ; or it may be a special culture medium into which the organism has been inoculated. Some specimens bear only one species of organism ; for example, tobacco leaves may be sent in with only *Cercospora nicotianae* on them. Often, however, specimens arrive bearing more than one species. Where two or more species are present they may grow independently of one another on the substratum, e.g. *Cercospora carotae*

and *Alternaria dauci* on carrot leaves, or one may grow on the substratum and the other be parasitic on it (a hyperparasite), such as a rust parasitized by *Darluca filum*. Where microscopic preparations alone are available, these are treated as specimens.

When specimens are sent to the herbarium for identification or checking each one is given a Herb. I.M.I. serial accession number. The packet in which the specimen is stored bears this number, all microscopic preparations made from the specimen bear the same number, and so do all cultures and subcultures made from it : drawings and photographs are similarly labelled. When more than one *species* is present on a *specimen* this is indicated by placing the letters *a*, *b*, *c*, etc. after the Herb. I.M.I. number. In this way each species which forms a component part of the specimen can be referred to precisely.

One species—one name

Just as each specimen is given one and only one serial accession number so each species is given only one name in the Herbarium. Where a fungus is known to have so-called perfect and imperfect states, specimens of the species, whichever state they bear, are all put away together under one name —the name we are currently accepting for the perfect state. For example, if we have two specimens one of which comprises rice plants bearing perithecia of *Cochliobolus miyabeanus* and the other rice plants bearing only conidiophores and conidia (often referred to in this condition as *Helminthosporium oryzae*), both specimens are laid away in the *Cochliobolus miyabeanus* folder. Cross references are given in the herbarium books.

A note to plant pathologists and other collectors

As a general rule, specimens other than cultures that are sent in for identification should be ample in quantity, well dried, and, in the case of leaves, carefully pressed before despatch. They should be well packeted and each packet labelled, the following minimum particulars being given on the label : the correct name of the host plant or other substratum ; the locality, given as precisely as possible ; whether wet or dry season ; the name of the collector and his serial reference number ; the date of collection. In the case of fungi such as agarics where colour changes occur on drying information about their colour when fresh should be given and, if possible, a spore print prepared. Delicate specimens such as myxomycetes and some entomogenous fungi should be firmly fixed in small boxes or other containers. If more than one organism is present on a

specimen and the collector is especially interested in one of them, a slide or drawing of this may be sent. When a slide is sent the part of the specimen from which it was taken should be marked. Pure cultures of organisms isolated from the specimens should bear the same serial number as the specimen. Where the collector has induced his organism to sporulate in culture part of the dried-down sporulating culture (see p. 33) should always be sent in addition to a fresh subculture. This is necessary because so often fungi which fruit readily when freshly isolated fail to form spores in later subcultures. Also many culture tubes arrive broken due to insufficient care in packing and become contaminated. When a letter referring to specimens is sent under separate cover a copy of that letter should always be enclosed in the parcel.

Where specimens come from

Most of the specimens sent to the C.M.I. for identification come from countries inside the Commonwealth and by far the largest proportion are sent in by plant pathologists. Plant and animal pathogens, moulds of importance in industry, and fungi isolated from soil in the search for new antibiotics come to be named. Sets of published exisccata are received from time to time from countries outside as well as inside the Commonwealth ; these serve to enrich the herbarium and are most welcome.

Why all the specimens ?

Mycologists are sometimes asked why they keep more than one specimen of each species in a herbarium ; surely one named specimen should be enough ! There are several important reasons for doing so. Many microfungi are extremely variable and it is seldom that the full range of morphological variation of the species can be seen from an examination of one or a few specimens. Again, little is known of the geographical distribution of many species and the authenticity of records is sometimes doubtful. Records cannot be checked if the specimens upon which they are based have been thrown away. This does not mean that every specimen of every common species from a country where the fungus is well-known should be retained, but when a specimen supports a new record this should always be kept. Another reason why we like to have large representative collections is that plant pathologists and others from different parts of the Commonwealth and mycologists from other

Top. A part of the Herbarium
Lower. Herbarium records

herbaria visit Herb. I.M.I. from time to time, and when they do they are encouraged to examine collections in the herbarium and to make slides from them. We also like students to work here, but can only supply them with material to examine if this is available in sufficient quantity.

WHAT HAPPENS TO SPECIMENS IN THE HERBARIUM

Report books

When specimens are sent in for naming they are usually accompanied by a letter of enquiry. These letters and brief details of the collections are recorded in a report book. The purpose of this book is to show at a glance what reports are outstanding at any time and to ensure that these are dealt with.

Accession Books

An entry is made for each specimen in a large, strongly bound ledger with pages 13 in. × 8 in. which we call an Accession book. The serial accession number allocated to the specimen is entered in a column on the extreme left of the left-hand page of the book, the country from which the specimen came and the name of the collector are entered in the next column and further details given by the sender follow. Usually two lines are allocated to each specimen. The right-hand page is reserved for details when the specimens have been identified and checked.

Labels and packets

Gummed labels, 2 in. × ½ in., printed in bright blue letters

Herb I.M.I. No.

are used extensively ; the serial accession number is entered in ink on this type of label which is then stuck on to the herbarium packet, culture tube, or other container in which the specimen is sent. Two other labels of the same size are used occasionally. Their use is restricted and they serve to draw attention to important collections :

Ex Type Coll.

labels are printed in red letters and

Authentic for the name

labels in green. If the packet in which a specimen arrives is in sufficiently good condition a label bearing the accession number is attached and it is ready to be examined by a mycologist. If the specimen is poorly packed, or is a culture or a slide, one of our own herbarium packets is prepared. These are made of stout, good quality paper and when folded measure 6 in. × 4 in.— laid out flat they look like this :

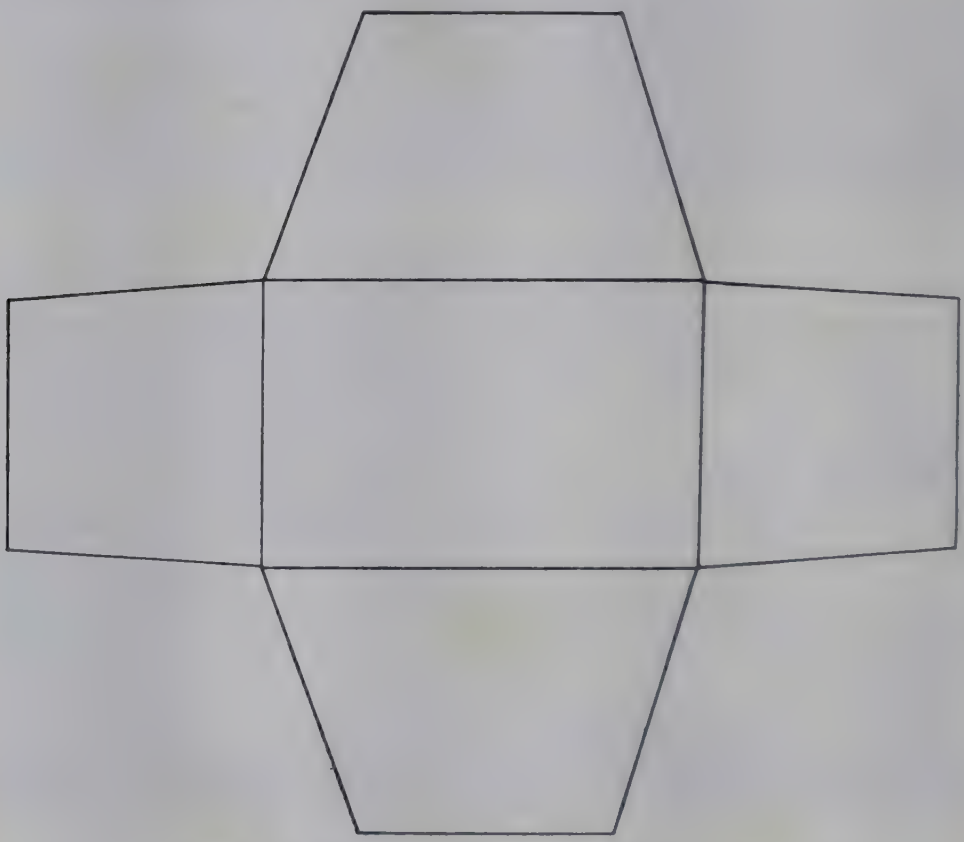

Fig. 1. Herbarium envelope unfolded

The two sides are folded in first, then the bottom flap, and finally the top flap so that folded they appear like Fig. 2 :

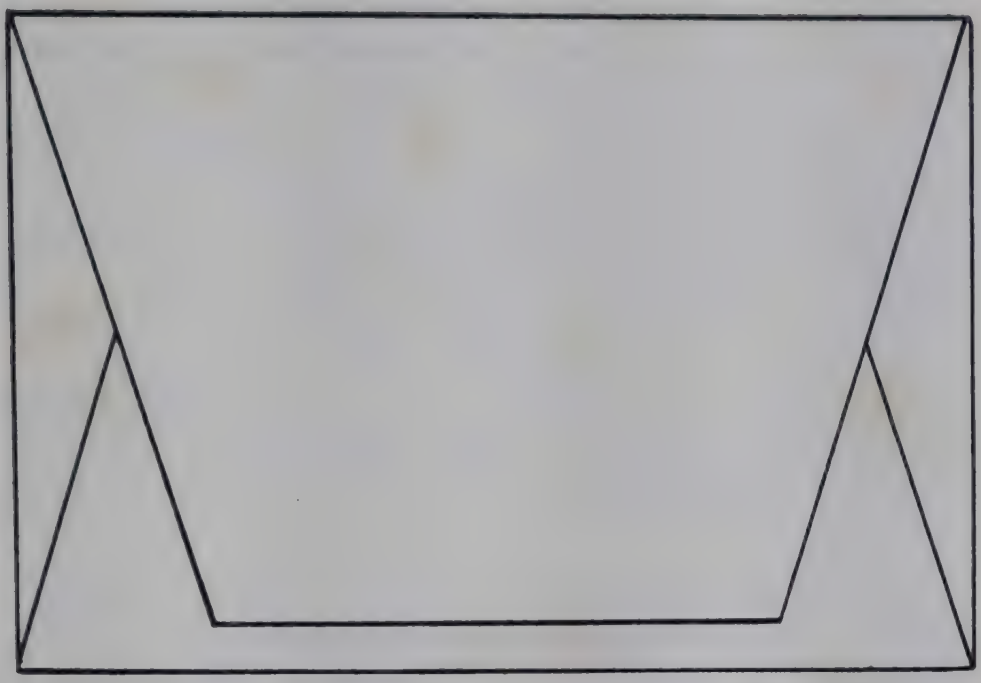

Fig. 2. Herbarium envelope folded

A printed 5 in. × 3 in. label is stuck on the front flap ; it bears the following inscription :

Commonwealth Mycological Institute

Name

Host

Loc.

Col.....Date

Det.....Herb. I.M.I.

No.

All relevant details are entered on this label.

EXAMINATION

Examining specimens

Specimens are examined by the mycologists. Each

mycologist has a lens, a binocular dissecting microscope, and a good compound microscope, usually provided with a quadruple objective nosepiece, revolving and centring stage, condenser sleeve with rack and pinion focussing, and a two-lens condenser N.A. 0·90, iris diaphragm and filter holder, ×10 or ×15 periplanatic micrometer eyepiece, 13/0·40, 25/0·05, 63/0·85 achromatic, dry and 100/1·30 achromatic, oil immersion objectives. One microscope in the herbarium is set up permanently for photomicrography. Everyone has a camera-lucida and the type with a large adjustable mirror on a long arm has proved the most satisfactory for our needs. Microscope lamps of ordinary pattern are used and top-lighting is provided by wall bracket lamps with strong moveable arms of the type commonly provided in factories.

Mountants used vary with the needs of the individual, but for most general purposes lactic acid and lactophenol-cotton blue are employed ; other stains available are thionin in aqueous phenol and 1% erythrosin in 10% ammonia. Nail varnish is used for sealing. Instruments include forceps, a fine scalpel or spear needle, mounted needles, and pieces of nichrome or platinum wire. Good quality microscope slides and $\frac{5}{8}$ in. square coverslips (Nos. 1 and 2) are used for most preparations. All drawings and notes are filed in standard loose-leaf binders which hold 500 pages of 5 in. ×8 in. ; plain bond paper is used for drawings, and feint-ruled paper for notes. A small but fairly comprehensive and well-indexed library of taxonomic books and reprints is kept in the herbarium.

As with most other groups of organisms the classification of fungi is based primarily on morphology, and in common with some other groups such as the algae it is the microscopic characters which are the most important. Before any attempt is made to identify a fungus microscopic preparations which demonstrate its structure clearly and precisely must be made. Sometimes a small colony of a fungus, scraped from its substratum, simply mounted on a slide in lactophenol cotton blue and warmed after the cover-slip has been put on provides a sufficiently good preparation, but often this is not enough. Thin sections may have to be cut with a freezing microtome, fragile colonies removed by the " necol " technique, single-spore isolations made, or slide cultures prepared. These useful but time-consuming operations are carried out by

technical assistants, details of some of the techniques they employ being outlined below.

Section cutting

All sections other than hand sections are cut with a freezing microtome ; small pieces of the substratum with the fungus are soaked in a weak solution of gum arabic in water for several hours—often 24 hours is essential—before they are mounted on the microtome stage for sectioning.

Necol mounts

These are often made when the fungus to be examined, one of the Microthyriaceae, for instance, grows on the surface of the substratum. The necol or a similar cellulose acetate preparation is thinned down with acetone until it flows like glycerine. A small drop of this fluid is placed on the fungus colony and allowed to dry ; this generally takes 15–30 minutes. A thin, colourless film or " flip " is formed with the fungus firmly embedded in it and this, when quite dry, may be eased off with a scalpel and mounted in pure glycerine, using the double coverslip method.

Instead of being mounted in glycerine the cellulose acetate can be washed away and the fungus itself mounted in lactophenol or lactic acid. To do this the " flip " is placed on a slide and acetone pipetted on to it. The cellulose acetate film dissolves and spreads out in a ring leaving the fungus behind, this ring is wiped off with a cloth. Repeated gentle washing with acetone, using a fine bulb pipette, clears away practically all the necol. Instead of lactophenol the " flips " may be mounted in euparol. The formula for a suitable cellulose acetate preparation which we make up is : four parts acetone, one part diacetone alcohol to which 1% each of benzyl abietate and triacetin have been added, plus cellulose acetate to bring the solution to the right consistency.

Slide cultures

Sterile conditions are very important when slide cultures are being prepared. The work is done under a sterilized Petri dish lid on a tile which has been cleaned with alcohol. Slides and coverslips are dipped in alcohol, flamed, and placed on the tile under the Petri dish lid. 7 mm. squares (2 mm. thick) of a

suitable agar medium (malt agar is often used) are cut out from a Petri dish and each one is placed in the centre of one of the slides. The agar blocks are inoculated at the central point on each of their four sides with a minimum amount of inoculum, sterile coverslips are put on and the slides placed in a damp chamber at room temperature, usually for seven days. A 6 in. Petri dish with the bottom covered by a sheet of filter paper or blotting paper, soaked in water to which 20% glycerine has been added, makes a good damp chamber, the slides being supported by short glass rods laid horizontally on top of the wet paper.

The fungi grow and often sporulate freely on both the slide and the coverslip, and the colonies can be examined in a living condition. When suitable for mounting, two preparations are made, one from the coverslip and one from the slide. The coverslip is lifted off and the agar block, which adheres to either the slide or coverslip, removed and discarded. Fungus colonies remain attached to the glass on the upper side of the slide and underside of the coverslip. A drop of a suitable mountant such as lactic acid or lactophenol, with or without cotton blue, is placed in the centre of the colony on the coverslip, which is then inverted on to a clean slide. Another drop of mountant is placed in the centre of the colony on the slide and a clean coverslip lowered on to it. The preparations are warmed and sealed in the usual way.

Sealing

When carefully sealed, slide preparations often remain in good condition for many years. No more than the minimum amount of mounting fluid necessary to fill the space between coverslip and slide should be used. Before sealing, slides are warmed, often for an hour or so, on top of the microscope lamp, and any excess of mounting fluid which oozes out is wiped off. Nail lacquer (bought in bulk) is used for sealing (see p.61) and is applied evenly along the edge of the coverslip with a fairly fine brush ; the slide must be quite dry before this is applied. The first seal is allowed to dry thoroughly, then a second layer is applied. The first seal should be made with colourless lacquer and the second with coloured lacquer. In this way one can tell at a glance whether one or two coats have been applied. If coloured lacquer is used for the first seal the colour sometimes diffuses out into the mounting fluid.

Slide boxes

Small, flat boxes, made from $\frac{5}{32}$ in. cardboard, with thinner cardboard for the bottom and hinged lid, each holding a single slide, are kept in the herbarium packets with the specimens. When slide boxes are put in the packets the specimens are enclosed in transparent paper envelopes to protect them.

CULTURES

Cultures in the herbarium

The culture media used are for the most part the same as those employed in other laboratories, and include potato-dextrose, potato-sucrose, potato-carrot, malt, maize, rabbit dung, oat, and Czapek agars. Fungi are also grown on lupin stems, elm twigs, wheat culms, and rice grains. There are eight incubators with temperatures ranging from room temperature to 37°C. Where difficulty is experienced in inducing fungi to sporulate the cultures are sometimes exposed to ultra-violet light. Subcultures of all fungi named are sent to the Culture Collection to be maintained, and sporulating cultures are dried down and incorporated into the herbarium.

Drying down cultures

Tap-water agar (1·5%) is melted and poured on to the smooth side of 4½ in. squares of ordinary commercial hardboard. The culture to be dried down is carefully removed from petri-dish or tube and placed on the melted agar. In the case of slope cultures agar from the thick part is sliced off to make them thinner and flatter. Old, dry, tube cultures can sometimes be loosened by heating a little water in the bottom of the tube. The hardboard squares, with culture, are placed under raised pieces of cardboard as a protection and the tap-water agar allowed to dry. It is ready to loosen with a razor blade, peel off, and trim after two to five days. If the dehydrated cultures have been allowed to become too dry this may be remedied by placing them in a damp chamber for about an hour. Dried down slope cultures are usually stuck down with gum in ordinary slide boxes—the edges are temporarily pinned down if there is any tendency to curl. Petri dish cultures are fixed to the under side of removable cardboard rings which fit into flat, cardboard boxes of special design ; the reverse as well as the obverse of these cultures can be examined easily at any time.

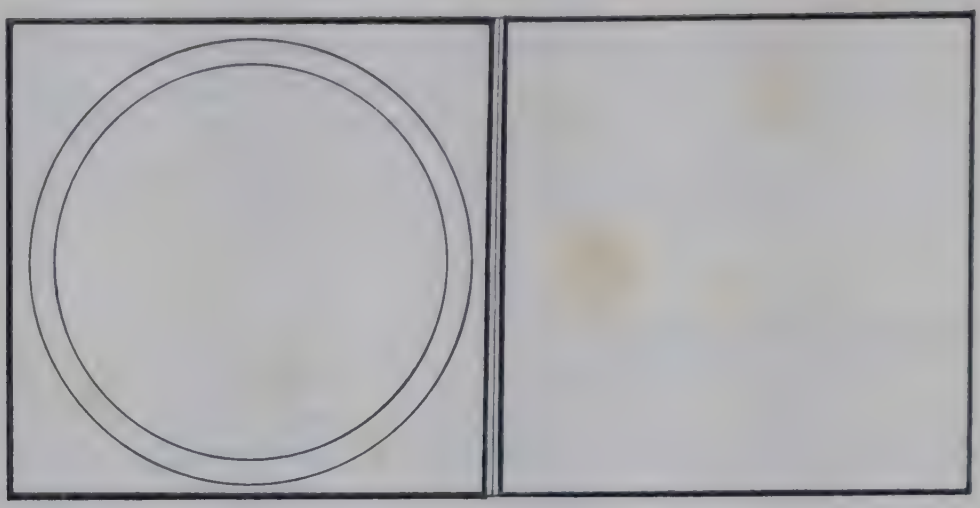

Fig. 3. Dried culture box

DISPOSITION

Indexing

When a specimen has been examined and named the name is written on the packet, which is then passed to the accession room for indexing. Even when a specimen cannot be named it is given a taxonomic species or genus number so that it can be put away with other similar specimens in the herbarium. The name given by the mycologist to the fungus is entered first of all on the right hand page of the *accession book*. Redispositions made at any future date are also shown on this page. Two further entries are made, one in a *fungus book* and the other in a *host book*. When this has been done a tick is placed against the entry on the left side of the accession book. The *fungus books* are loose-leaf notebooks with 10 in. $\times$ 8 in. sheets of feint-ruled paper. At least one sheet is provided for each fungus name used in the herbarium and the sheets are filed in alphabetical order. The fungus name and the author or authors of the name are typed in the top right-hand corner. The accession number, substratum, country of origin, and date of collection of each specimen of that species are recorded in ink in the space below. When a specimen is redisposed the species name originally applied to it, linked with the name under which it is now kept, is recorded on a " Misdetermination and synonym " sheet which is filed at the end of each genus. The *host books* are similar loose-leaf notebooks with at least one sheet provided for each host genus or other type of classifiable substratum. The name

Fumigation cabinet

of every fungus on each substratum which is represented by a specimen or slide in the herbarium is entered on these sheets. A *genus disposition book* is provided to show the whereabouts in the herbarium of every fungus genus folder ; this is particularly useful to newcomers and visitors. The name of every species represented in the Herbarium is indexed on 6 in. × 4 in. cards under its epithet. When the original description of any species is looked up the literature reference is entered in ink on these *epithet cards*, obligate synonyms being put in when these are known. In this way a literature index is steadily built up.

Disinfestation

Before specimens are put into the herbarium cases they are always fumigated against insects and mites by exposure to methyl bromide in a fumigation chamber for 24 to 48 hours. Periodic refumigation of specimens in their folders is done. Whilst folders are in the gas chamber being refumigated the herbarium cases are sprayed with lindex.

Putting away specimens

After specimens have been numbered, named, indexed, and fumigated they are finally put away in the Herbarium. The packets containing specimens are stuck with gum arabic on to thick, white paper *herbarium sheets* 16½ in. × 10 in. ; at least six packets can be mounted on each sheet. All specimens of the same species are put together on these sheets, which are then placed in *species folders* (sheets of plain, white paper folded down the middle to fit over the herbarium sheets). The species name is written in graphite pencil in the bottom right-hand corner on the outside of the folder. Species belonging to the same genus are usually kept in alphabetical order in strong, brown, thin card *genus folders*, which are slightly larger than the species folders ; for rusts, smuts, downy mildews, and similar fungi which are host limited the species are filed under their host families. The genus folders are stored in taxonomic order in wooden herbarium cases. Small, removable, stencilled card labels on the outside of the doors indicate what is inside each case.

As a precautionary measure, when a herbarium assistant is putting away any specimen, she checks in the accession book its number and name, sees that a tick has been put on the left-hand page, indicating that an entry has been made in the fungus and host books, then puts a tick against the name on the right-hand page to show that the specimen has been put away.

Large specimens

Specimens are occasionally too large to be put into packets. If they cannot be split up they are stored in glass-topped boxes in drawers. Often, however, they can be cut to a suitable size with the help of secateurs, a fine tenon saw, a strong knife, or chisel and a hammer ; a bench vice is used to hold them firmly.

Duplicates

To provide suitable specimens for exchange with other mycological herbaria, large collections are often divided up. Each portion is examined carefully to ensure that the right fungus is present, and it is then packeted, labelled, and placed in the duplicate collection. A register is maintained showing which specimens have been sent to various herbaria.

ON STARTING A MYCOLOGICAL HERBARIUM

It is hoped that this brief account of what goes on in Herb. I.M.I. will help all those who have to start new herbaria. The importance of numbering specimens cannot be stressed too strongly. An accession book should be started and serial numbers allocated to specimens right at the beginning. The small, gummed accession number labels on which the abbreviated title of the herbarium has been printed in a bright colour will be found most useful. Loose-leaf fungus and host books become increasingly important as the herbarium grows, or one of the modern " visual " index systems may be adapted.

HOW TO DESCRIBE A FUNGUS

F. C. Deighton

Examination of the Fungus

Make sure you learn as much as possible about the fungus you are dealing with, by examination of all available material both under the binocular microscope and by high magnification ; also by examination of sections and of cultures when this is possible. Make sure that you have a thorough idea of the range of variation within the species. Make sure that you can recognise the fungus with certainty and distinguish it from closely related forms.

Write down a detailed description. It is helpful to use a standardized form of description.

Draw the fungus with the aid of a camera lucida, showing all the diagnostic characters. Check measurements and other details against your written description to make sure that they agree and that you have not omitted any character which may be of importance.

Search the literature thoroughly to see whether or not any fungus has been described bearing any resemblance to the fungus you are examining, either on the same matrix or on similar matrices (e.g., if saprophytic, on dead or moribund material from a similar locality or, if parasitic, on plants of the same or related host families). Remember that the fungus may have been described as belonging to some genus which, though to modern concepts remote from the genus which you are considering, may have appeared in earlier times to be related because of spore septation or some other gross character.

Obtain, from examination of other available material, an idea of the host range of the fungus.

If the fungus is morphologically indistinguishable from another on a different substratum it is preferable (in the absence of cross-inoculation experiments) to designate both by the same name. Should one morphologically identical taxon prove later to comprise two or more " forms " or " strains " each restricted to certain specific substrata, such taxa may be distinguished as *formae speciales* (i.e., differing not morphologically, but only in physiology, from each other). In certain fungus groups it has been customary in the past to distinguish such taxa as different species or varieties, but though this may

be useful in certain genera of strictly parasitic and proved host-limited taxa, its practice in other genera is likely to make for confusion. In some of the more widely distributed species of Uredinales of economic importance (e.g. *Puccinia graminis* Pers.) on which a great deal of work has been done, even the concept of a *forma specialis* has proved inconvenient and the several hundred strains which can be distinguished by the reaction they produce when inoculated on certain standard varieties of cereals are designated " races," with a distinguishing numeral. Subdivision of " races " has been made in some cases.

Describing a new fungus taxon

Taxa, below the rank of Family and Subfamily, recognized by the International Code of Botanical Nomenclature, 1956, are (in this order) : genus, subgenus (or section), species, subspecies, varieties and form (including *forma specialis*). A " race " or form indicated by a numeral has no status under the Code.

A Latin diagnosis is now obligatory [Art. 34] for valid publication of any of the above taxa recognized by the Code, and should include at least all the important details which characterize the new taxon and by which it can be distinguished from other related taxa. A fuller account may be added in a vernacular. An illustration should show all the important details mentioned in the diagnosis, and there should be a clear indication of the scale of magnification. It is also valuable to indicate the specimen on which it is based. [See Recommendations 45E, 45F, 45G.]

For the valid publication of the name of any new taxon of the rank of Order or below, it is now essential to indicate the nomenclatural type [Art. 35.] The type of a genus is, of course, a species.

In the case of microfungi, the " type " usually consists of a collection of leaves, twigs, bark, etc., on which the fungus described is present either alone or mixed with one or more other fungi. In order that other workers may be able to find the type and to re-examine it, it should be given some serial number which will not be duplicated : either a collector's serial number or a herbarium accession number. If there is more than one fungus present on the material, it is desirable that they should be distinguished by the addition of (a), (b), (c), etc., or by some cypher, after the collector's or the accession number. It is also highly desirable that the place where the type collection

is permanently conserved be indicated [Recommendation 35 A], and it is advisable for general convenience of future workers that this should be in some recognized herbarium (see *Regnum Vegetabile*, 15, 1959—*Index Herbariorum*, Ed. 4). The indication of the type should, for convenience, follow immediately the Latin diagnosis.

LABORATORY METHODS IN USE IN THE CULTURE COLLECTION, C.M.I.

H. A. Dade

The Culture Collection is primarily a living part of the taxonomic reference material of the C.M.I. It has other functions as well. It is a " public collection " from which cultures can be obtained on payment of a nominal fee : we now send out about 1,700 per annum. Rather more than half of these go to industrial concerns, where they are used for organic synthesis, for biochemical assay, and for testing mould-proofing processes. The remainder go to research workers and to educational establishments. We have accumulated a large number of interesting fungi specially useful for teachers, whom we also help with advice. We have free exchange arrangements with all the large foreign collections, a great and mutual advantage.

The strong taxonomic bias of the Institute's work has had an important and salutary influence on our outlook, and since the foundation of the Collection in 1947 we have been guided and inspired by E. W. Mason's conception of the fungus kingdom. While cultures are useful and perhaps indispensable in taxonomic investigations we are always aware that their value is strictly limited, for the behaviour of fungi *in vitro*, with all the unnatural conditions of artificial culture, can never be regarded as strictly representative of their behaviour in nature.

The cultivation of micro-fungi is still almost wholly an empirical art. Many years ago, Dr. Johanna Westerdijk, the former director of the Centraalbureau voor Schimmelcultures at Baarn, Holland, and a pioneer in this work, described it as small-scale gardening ; it is precisely that—we learn by experience and hit-and-miss methods, and results are often uncertain. For example, it may be difficult to find a suitable medium for growth ; some isolations never do well, we have occasional trouble with contaminants, infestations, mutations, and even parasites. The observations which follow indicate some general principles which guide our practice.

PURE AND MIXED CULTURE

What seems to me to be remarkable is not that we often have difficulty in persuading fungi to grow or to continue to

grow in good shape but that they ever grow at all in the conditions of artificial culture. Wild beasts in a zoo are much better off. Nothing could be more unnatural than the environment of organisms *in vitro*. In nature, fungi do not grow in pure culture, on unaerated jelly, on rich extracts often heavily laced with sugar from which solid matter is commonly (but not at the C.M.I.) carefully removed by filtration, nor in poorly ventilated glass vessels which exclude the last traces of ultra-violet radiation that may have penetrated glass windows and a few additional sheets of glass in incubator doors, etc., or even shut up in dark cupboards. We can ameliorate some of these horrors, but by no means all of them. The whole technique is fundamentally unsound, but it is difficult to see how it can be changed.

However good we may be as field naturalists, we may tend to lose our field sense when we go into our laboratories and become involved with brass and glass. It should be remembered that the conditions of growth in nature, so far as we understand them, often provide clues to the treatment of fungi in culture. But we know far too little about micro-ecology, which is indeed a most promising field for research.

In nature, fungi grow in association with other fungi, with bacteria, actinomycetes, protozoa, and other organisms. Their isolation in pure culture is the first fundamentally wrong treatment, but for obvious reasons we must often apply it. All the " undesired " organisms are discarded, yet one or more of them may be an essential symbiont or commensal. (Recent attempts to broaden the definition of the word " symbiosis " has created so much confusion that a suitable term is hard to find, and here I mean to imply only that one organism may not grow, or will fail to develop completely, in the absence of another). This phenomenon is probably much more common than may be supposed although many cases have been reported and others are known. The following are examples.

Heald and Pool (1909) found that *Melanospora zamiae* would produce perithecia only when grown with *Nigrospora oryzae*, *Gibberella fujikuroi*, or, less successfully, with *Fusarium culmorum* and mention that *Sordaria longicaudata* could form perithecia only after *Pilobolus* had grown on the horse dung used as a medium. Before that date Molliard (1903) had shown that *Ascobolus* is similarly dependent on the presence of bacteria. McCormick (1925) succeeded in getting perithecia of *Thielavia*

basicola in mixed culture with *Thielaviopsis basicola* and some other fungi, or on extracts or killed cultures of them. Mason (1933) observed that *Acremoniella atra* and *A. verrucosa* would not grow at all unless in company with a *Cephalosporium* sp., and also that *Melanospora damnosa* would produce perithecia only when grown with *Thyridaria rubronotata*. Dade (1937) found that *Thielavia setosa* required the presence of *Aspergillus flavus* (or other moulds), or killed cultures, for the production of perithecia. Petch (1925) had a similar experience with *Melanospora parasitica* and its associate *Cephalosporium longisporum*, and we have found that the latter stimulates other *Melanospora* spp. to some extent, as do other *Cephalosporium* spp. naturally associated with *M. zamiae*. Some years ago we received a culture of *Ceratocystis* sp. "contaminated" by *Gonatobotryum fuscum*. When they were separated the *Ceratocystis* remained obstinately sterile; when they were reunited large crops of perithecia were formed. *G. fuscum* was then introduced to two South American isolates of another *Ceratocystis* sp. which had never formed perithecia but had been tentatively identified by their conidia. Dense stands of perithecia were then produced, and the earlier provisional identification was shown to be incorrect. More recently a new and remarkable member of the Mucorales, not yet described, has formed its sporangia only in the presence of bacteria derived from the natural substratum, leaves, and found in the first isolation plates.

For the purpose of maintaining a valued organism in good condition there can be no objection to keeping it in mixed culture. Sometimes we have the choice of a number of companion species, and then we can choose one which will not overgrow and choke its principal. The most satisfactory companion is one which has an equal, or slightly slower, rate of radial growth. If the principal's requirement is some metabolic substance produced by the companion we may be able to supply this substance and thus obtain full development of the principal in pure culture. It seems often, perhaps generally, possible to obtain the required substance by growing the companion in a liquid medium and then passing the fluid through a Seitz filter, after which it can be added to the medium on which the principal can be grown in pure culture. Sometimes, as in the cases of *Thielavia basicola* and *T. setosa*, satisfactory results ensue when a young culture of the companion is killed by heating (which

should not be excessive) and the principal is planted on the same slant or plate.

Biochemical investigation of this phenomenon as well as of other problems of artificial culture might be expected to produce valuable and far-reaching results.

Light and Temperature. Incubators

We can ameliorate some of the bad conditions in which fungi are often grown by the application of commonsense and experience. We know that bright light, often direct sunlight, is favourable to sporulation in the majority of our cultures, and we therefore grow our fungi not in the conventional type of incubator but in plate glass cabinets of the kind used in grocers' shops for displaying food, fitted with glass shelves and sliding glass doors. These are roomy, well ventilated, and very convenient. Ordinary room temperature suits most fungi quite well, and there is no need to provide heating apparatus or thermostatic control in most of the cabinets. We have two or three orthodox incubators for the relatively few organisms which do better in darkness or require higher temperatures, and these are also used for checking optimum temperatures when we are identifying certain moulds ; but they are always half empty. From these incubators we have removed the original unreliable controls and have replaced them by Sun Vic thermostats, which are easily adjusted over a wide range of temperature, are sensitive, and never give trouble.

Some of our glass cabinets are placed in windows. These are cold spots in winter, and to keep them up to the normal room temperature (between 65° and 70° F.) we lay in them heating wires of the kind used for preventing water pipes from freezing ; these are cheap and uncomplicated, and are quite safe as they do not overheat.

Those fungi which in nature grow and sporulate in bright light may be expected to do better when incubated in the best light that we can provide, and this is what usually happens. *Pyronema*, *Alternaria*, and *Choanephora* are examples of genera which demand very intense illumination, and they do best in direct sunlight. The coprophils, and discomycetes generally,

also respond to strong lighting. An isolation of *Lachnea cretea* which had been sterile for eight years produced apothecia when exposed to direct sunlight.

CULTURE MEDIA

We are still very ignorant of the nutritional requirements of fungi, and we have to rely largely on trial and error like the gardener, slowly gathering empirical data. Some general principles, however, do emerge. The formulae given in text-books of mycology and plant pathology are for test media, concoctions which have proved generally useful for encouraging lush growth of fresh isolations. They usually contain large additions of sugar as an easily assimilable source of carbon. Though media of this kind are used by mycologists and pathologists engaged in research on life histories or taxonomy, they are by no means generally suitable as conservation media, the purpose of which is to keep fungi in good condition for as long as possible. The experience of all who have tried to keep microfungi in culture long enough to involve a few successive transfers will confirm Langeron's (1945, pp. 446–8) denouncement of monosaccharides, especially glucose, as sheer poison, inducing sterility in a relatively short time. Langeron was particularly interested in dermatophytes, which are notoriously prone to deterioration *in vitro*, but most other fungi, even the common moulds which have become domesticated, are similarly susceptible. The majority of fungi do not find rich feasts of sugar in nature : they have to work hard for their living, converting starch or cellulose into assimilable form, usually encountering sugar in small quantities. When they are translated to the luxury of potato dextrose agar or malt extract agar they respond exuberantly at first, but after a few transfers cease to sporulate and fill their culture vessels with masses of sterile, aerial mycelium. Perhaps we should avoid doubtful parallels by referring to the effects of high living on humans and their domestic animals, but the comparison is tempting.

Conservation media

There are, of course, exceptions, but induced sterility is so common that it suggests a general guiding principle : to avoid sugars, especially monosaccharides, and particularly glucose, as far as possible in conservation media, and instead to supply

carbon in the form of starch or cellulose. When sugar must be used, it should be the minimum necessary to support fair growth, which is very much less than in the usual formulae. Langeron's weak potato-carrot medium (PCA) is one of the most useful media that we have, containing, in each litre, only 20 g. carrot and 20 g. potato, the only other constituent being agar. It inhibits aerial mycelium, but not sporulation, growth is rather sparse, but healthy ; and on it a great many fungi can be maintained for years without deterioration, showing the usual lush growth and sporulation when they are transferred to test media.

Those fungi which possess cellulolytic enzymes can digest cellulose, especially in the form of filter paper, and seem to prefer it to other carbon sources. The common practice is to tear it up into small scraps and add these to the agar, when most of the paper sinks to the bottom of the vessel, where it remains out of reach. Our method is to apply strips of sterile paper to the surface of slants, usually PCA, with flamed forceps. Response is sometimes spectacular. *Stachybotrys atra* and *Memnoniella echinata* sporulate very profusely on the paper, which becomes evenly black with spores, but scarcely at all on the agar. *Chaetomium* and some *Sordaria* spp. and related fungi also do very well. *Pyronema domesticum* also requires readily available cellulose and will not form fertile apothecia without it, but this fungus also demands strong illumination, preferably direct sunlight, as well ; *both* factors are essential.

Hansen and Snyder's (1947) fumigation method is used in preference to heat for sterilizing the filter paper. It not only eliminates the damage caused by heat, but is very much simpler. The filter paper is first cut into small strips of suitable size (in our case about 40 mm. 12 mm.) and placed in a squat, screw-capped jar. One ml. of propylene oxide is added, and the jar closed. By next morning the paper is quite sterile. Propylene oxide is so volatile that all traces of it disappear during the transfer of the paper to the slant.

Propylene oxide fumigation is also useful for cold sterilization of powdered, organic nutrient material, such as pea straw, for which it was originally recommended by Hansen and Snyder. The sterile powder is sprinkled on the surface of tap-water agar, which provides the necessary moisture for growth. The gas

has poor penetrating powers, however, and will not sterilize granular material. We use a small electric sample mill for pulverizing stems, etc. It is sometimes possible to sterilize thin leaves, and thus to obtain sporulation of leaf parasites which cannot be induced on orthodox media. Glassware can also be sterilized by this method when it is desired to avoid using the hot air oven.

Special media

Sugars have their uses and we use sucrose in large quantities in preparing media of high osmotic pressure. A well known example is the malt extract plus 20% sucrose (M/20) commonly used for promoting production of conidial sporulation in members of the *Aspergillus glaucus* group. An even higher concentration of sucrose (M/40) is required to induce sporulation in *Eremascus albus*. The moulds which damage the lenses of optical instruments in the damp tropics (abnormal strains of *Aspergillus glaucus*, *A. fumigatus*, and *A. versicolor*, and probably others) will not grow at all, or make only very slight sterile growth, on normal media, and may therefore escape isolation ; but they will grow readily and sporulate freely on M/40. Recently we failed to obtain growth of *Xeromyces bisporus* until we added 60% sucrose. Other fungi will grow quite well on normal media, but have some mechanism which protects them from plasmolysis and enables them to grow also on very highly concentrated salt or sugar solutions. An example is *Sporendonema sebi*, which is able to grow and sporulate in the presence of a saturated solution of common salt. A physiological study of this remarkable phenomenon would probably give interesting and useful results.

Sabouraud's test and conservation media are in regular use by medical mycologists for the cultivation of dermatophytes, but they are by no means suitable for other fungi, which make very poor growth on them. Peptone often inhibits growth, and there seems to be very little point in offering it to fungi, except, apparently, to dermatophytes and some chytrids. Adding yeast autolysate to our media has also proved unsatisfactory, and it appears that in general there is little to be gained by including aneurin.

We prefer organic to synthetic media, considering, like Langeron (1945, pp. 439–440) that the latter are " detestable."

When we make up a synthetic we do not know what we are putting in, since even analytical chemicals are not pure, or what essential trace elements we are leaving out. When we use decoctions of organic materials we have a much better chance of giving fungi what they require, whatever that may be. The conception of a " standard " synthetic medium is a fantasy. The only synthetics which we use are Czapek-Dox for the identification of *Penicillium* and one or two special media for abnormal industrial strains.

Most of the usual test media are included in our repertoire, though in most cases with reduced sugar. We do not, however, find that prune and cherry decoctions or corn steep have any special virtues, nor have nearly all the " new " or " special " media which are vaunted from time to time in literature. Beer wort rarely shows any superiority over malt extract.

Our best conservation medium is, as has already been stated, PCA. Corn meal agar (CMA, 30 g. maize meal per l.) is generally useful for fungi which need more nutrients than is provided by PCA. Oat agar (OA, 30 g. powdered oatmeal per l.) is another valuable medium, and it is always used for *Phytophthora*, *Pythium*, and several others. We make much use of rabit dung agar (RDA), adding two or three whole pellets to each slant of tap-water agar, or four or five to plates. Better results are obtained by using whole pellets partly submerged in the agar than by breaking them up and dispersing the fragments. This medium suits many fungi other than coprophils. Sterilized garden soil, with no added agar, is our conservation medium for *Fusarium* spp., reducing, it is believed, the chances of mutation. Occasionally we use sterilized maize, peas, stems, bread, etc., without agar, as test media or for demonstrations. On them viability is short, no doubt because they quickly become dry, and they are of no use for routine maintenance.

Soft agar easily breaks and is reduced to mush under the shocks of postal transportation, so we use rather larger proportions of agar than is usual, i.e., 25 g. per l., or 20 g. in the case of CMA and OA, where the other constituents stiffen the medium.

Preparation of media

In the Culture Collection we have never used the archaic

method of preparing media in flasks over Bunsen burners. In our early days we used double enamelled steel saucepans, heated on gas rings, a much less precarious procedure. When we moved into our present quarters we installed a domestic gas cooker : making media is, after all, only cookery. The advantages of this were at once obvious. We can heat four pans at once on the top of the cooker, and we use the oven for sterilizing Petri dishes and other glassware, in the usual cylindrical metal boxes, adequate control of temperature being provided by the Regulo valve. The cooker costs about half as much as a conventional copper, hot-air oven, such as is normally used for glassware.

Two 15 in. autoclaves are in use. These small autoclaves are said to be more efficient than larger ones. A basket full of our culture bottles weighs about 60 lb., which is too heavy for women assistants to lift awkwardly out of the autoclaves. Blocks and tackle have therefore been installed above the autoclaves, and a slotted-angle trolley is used to move the baskets to the very large, low table where bottles are slanted and set out to cool.

The relatively large scale of routine cultural work is reflected in the quantities of glassware which have to be cleaned. To expedite washing operations we have a large, double stainless steel sink with running boiling water, and a bottle-washing machine (Thomas Hill Engineering Co., Hull) with nylon brushes of different sizes.

Culture bottles

The screw-capped culture bottles designed by Dr. J. E. McCartney were first made for the pathological service of the London County Council and were adopted by the medical services of the Allied Forces during the war of 1939–45. When the culture collection of the C.M.I. was founded in 1947, two sizes of McCartney bottles were taken into use. Our standard bottle is the 1 oz. " Universal Container " (fig. 4A), originally designed not as a culture vessel, but for specimens of sputum, etc. It is a wide-mouthed bottle, and more suitable for our purposes than the narrow-mouthed types favoured by bacteriologists. Fungi appear to thrive better in the wide-mouthed

Top. Culture Collection laboratory
Lower. H. A. Dade in a corner of the Culture Collection laboratory

form, perhaps because ventilation is more efficient, and the large mouth facilitates the insertion of filter paper strips and the removal of cultures, intact, for drying as herbarium specimens. They should be ordered as " J.669, Universal Containers, 1 oz., with aluminium caps, black rubber liners, cleaned ready for use." The black rubber is a non-toxic material, unlike red rubber. The ½ oz. " bijou " bottle (fig. 4B) is used for sending cultures by air mail.

McCartney bottles have several advantages which are particularly valuable in a culture collection. They are durable and can be used over and over again ; the expense and labour of making cotton wool plugs is eliminated ; cultures dry up much less quickly than in plugged tubes, though the screw caps are, of course, loosened to permit respiration ; the bottles stand without support, making test-tube racks unnecessary ; cultures can be stored very compactly in trays and can be found quickly, the accession numbers being written on the caps with grease pencil ; labels can be attached behind the slants, where they do not obscure the view of the surface of the medium. The greatest advantage of the bottles, however, is that large quantities of medium can be stored in them indefinitely without loss through drying, for the rubber-lined caps, screwed down after sterilization, prevent evaporation and contamination. It is, of course, a great economy of time and labour to prepare media on a large scale, instead of frequently making small quantities. We make batches of media at the most favourable times, for example, when potatoes are in good condition (new potatoes are not suitable), or when carrots, some fruits, and such materials as pea straw, are in season.

The bottles also have disadvantages, some of which gave us some bad moments in the early days of the collection, but these are trifling when compared with their advantages. The bottles are of rather thick cast glass and cultures cannot be easily examined with a lens, but we do not find this of much consequence in practice. A more serious disadvantage is that the bottles, when their caps are left loose after inoculation to permit respiration, are very liable to infestation by mites. But we have succeeded in controlling these pests (see p.57), and now have no difficulty at all.

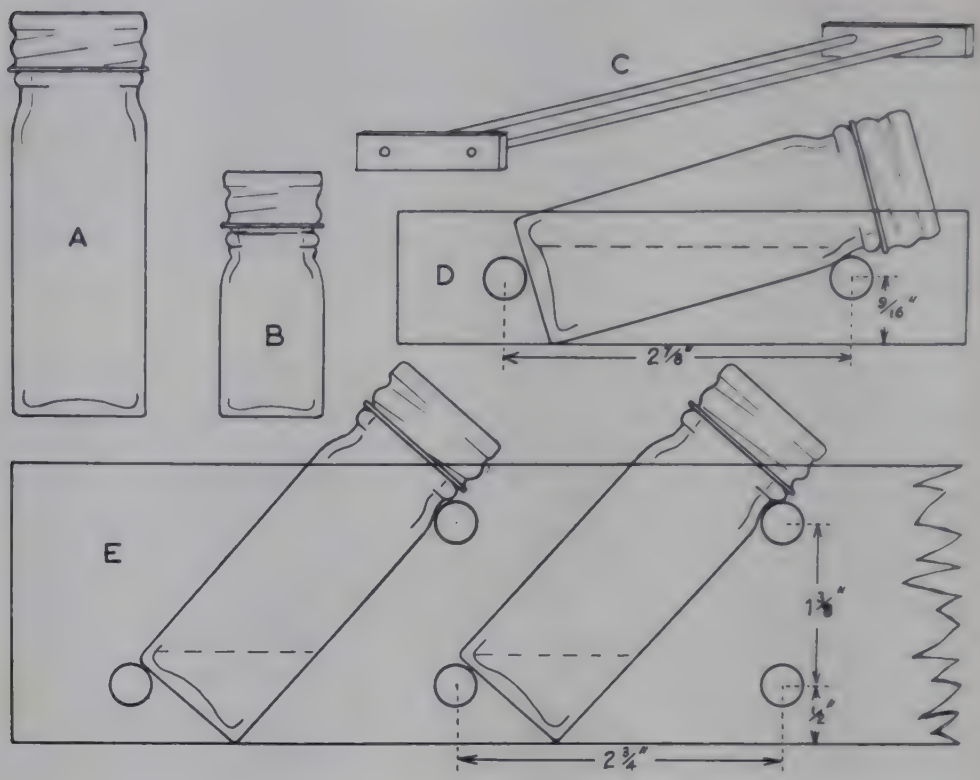

Fig. 4. A, the McCartney 1 oz. Universal Container ; B, the ¼ oz. " bijou " bottle ; C, slanting rack for long slants ; D, the same, in profile, showing dimensions ; E, slanting rack for short slants, in profile, with dimensions

During autoclaving and slanting, the caps of the bottles are slightly loose, for if the caps are rather tight the rubber liners are likely to be sucked into the bottles as they cool. Slanting is simplified by racks designed for the purpose (fig. 4C & D). They are constructed of battens and dowel rod, and ensure that the angle of slant is correct and uniform. Slant bottles contain 7·5 ml. of medium ; " short slants " (for oiling) contain only 5 ml. Bottles, for 10 cm. Petri dishes, contain about 17 ml. of medium and are not slanted. When the bottles have cooled to ambient air temperature, and not before this, the caps are screwed down. No special conditions are necessary for the storage of media, except protection from dust, and the media remain in perfect condition for several years, at least, though they seldom lie in store for so long.

AT THE BENCH

Routine transfers are performed at the open bench, without special precautions beyond ordinary cleanliness and the avoidance of draughts. Special equipment and precautions against air-borne contamination may be necessary in certain localities, as, for example, in very dry, dusty situations, or where there are prolific sources of air-borne spores as places where *Neurospora* flourishes on regularly burned bush. *Neurospora* is undoubtedly the most troublesome laboratory weed, and special precautions are sometimes necessary to control it. With these exceptions, however, culture rooms or hoods are rarely necessary and they can be the cause of much nuisance and waste of time and labour. Such has been the writer's experience in such widely different conditions as those of West Africa and Kew, and, according to the many visitors to our laboratory, it appears to be generally true. It is much less trouble to deal with an occasional contaminant.

Laboratory weeds have not given us much trouble here, but through earlier experience the writer was fortunately alive to the danger when the artificially induced mutants of *N. crassa* and *N. sitophila*, used for biochemical assay of the vitamin B group, were acquired for the Collection. Obviously special precautions were essential to insure against contamination of these strains by one another, which could not be detected except by biochemical tests and which would render the strains useless. At that time we were working in the old building in very cramped conditions, with no room at all for the conventional type of hood. The writer was therefore forced to devize an effective miniature hood, which may prove useful to others and is worth describing in detail.

The air space under control is limited to the immediate vicinity of the culture bottles and the inoculation needle. The hood is a small wooden box with a fixed glass side to admit light and a removable glass lid through which the work can be seen. The glass sheets are half-plate negative glasses, 6½ in. × 4¼ in., easily replaced in case of breakage (fig. 5*g*). At one end, near the top, is a hole *a*, 1 in. in diameter, covered with a piece of sheet rubber (car inner tubing) ; this sheet is pierced by a small hole in which is tightly held a brass cylinder *b* holding the handle of the inoculation needle, which should slide freely. This simple assembly forms a universal joint permitting move-

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MYSORE

ment of the needle in all directions inside the box. At the other end of the box (fig. 5D), and near its bottom, are two oval holes also covered with rubber sheet, *c*, in which $\frac{7}{8}$ in. holes are punched through which the culture bottles are inserted and fit closely. The two bottles (stock culture and new slant) are now capable of free movement. A wooden strip *d* is screwed to the bottom and back of the box at a suitable angle (20° from the vertical) ; it has two holes, 1·2 in. diam., opposite to the bottle holes in the end of the box, in each of which are tacked three strips of rubber, *e*. The screw caps of the bottles can be pushed into the holes, and are held firmly by the rubber strips. The box is painted, inside and out, with white cellulose paint.

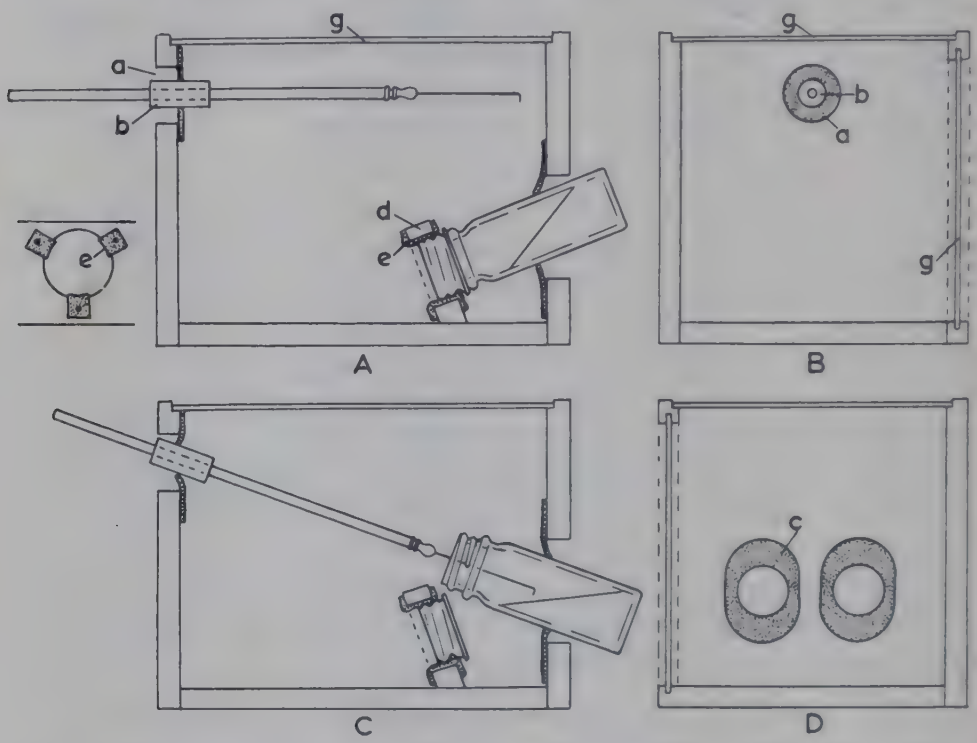

Fig. 5. Miniature culture hood. A, needle ready for use and bottle inserted, front elevation ; B, end of box, showing needle housing ; C, bottle and needle in position for transfer ; D, end of box with holes for bottles. *a*, hole for needle universal joint ; *b*, brass cylinder ; *c*, perforated rubber sheet for bottles ; *d*, wooden strip with holes for caps and rubber strips *e* ; *g*, glass

The box being clean, the needle is flamed and inserted, butt end of the handle first, into its housing, and the glass lid is put on. The caps of the bottles are flamed and pushed through the

holes in *c*, and the caps are pressed into the holes in *d* (fig. 5A). The bottles are then screwed out of their caps, which remain in *d*, and are turned upwards, pointing at the needle. The needle is manipulated, taking inoculum from the stock culture and transferring it to the new slant, (fig. 5C). The bottles are then returned to their caps. At this point, the box is taken out of the laboratory to another room where the bottles are removed from the box. The empty box is immersed in a bucket of water and detergent, all free spores being thus expelled or caused to adhere to the sides of the box. The hood can then be used again at once.

When inoculum of *Neurospora* spp., or of other potential laboratory weeds, is taken from an oiled culture (see " The Oil Method," below), there is no danger of airborne spores escaping, and it is then not necessary to use a hood.

Though the need has not arisen in our laboratory, one can imagine modifications of the miniature hood to make possible its use with plugged tubes (spring clamps to grip the plugs, carried on rods in universal joints) and Petri dishes (vertical sliding rods tipped with rubber suckers which could be applied to the lids of the dishes).

Culture bottles are labelled before transfers are made, and assistants who do routine transfer work are trained to compare carefully the labels on stock cultures and new bottles before making each transfer. The labels, which show the accession number, the name of the fungus, medium, and date, are printed in sheets of twenty-four. It is much easier to write on large sheets than on small individual labels. Accession numbers are written on the caps of bottles immediately after each transfer is made.

Two technical assistants work in the Collection. The senior carries out preliminary studies and trials of new accessions, makes slides of them, prepares forms for the culture record file and the catalogue entry cards which are temporarily filed in readiness for the next supplement to the Catalogue. She also deals with occasional contaminations and cases of deterioration, which can sometimes be cured by plating and re-isolation ; she prepares cover-glass cultures (p. 64), makes isolations, and assists in our experiments on new or improved techniques. The junior assistant performs all the routine transfers for maintenance and distribution, prepares stains and

stock solutions, etc., and assists in making media. She also understudies the senior assistant.

STORAGE

The Oil Method

The whole collection is stored under mineral oil, a very simple method of proved efficacy in extending viability (Wernham, 1946). The oil used is sterile liquid paraffin of British Pharmacopeia quality. Protected in this way, cultures remain alive for several years. We have as yet very little definite evidence of the limit of viability, but many cultures of our first pilot experiment, begun ten years ago, are still alive, and those which have not survived have been lost through no defect of the method in principle, but through contaminations resulting from our first faulty techniques. Our present system of sub-culturing at intervals of two years, keeping the oldest, next oldest, and most recent transfers, will in time provide information indicating the safe period of storage for a large number of species.

The oil method reduces the labour of routine replanting, necessary at intervals of six months in the case of orthodox unprotected slants. A large number of our isolations are maintained on " dry slants." These are fungi for which we are very frequently asked, and delivery time is saved for our clients by using the dry slant stocks as sources of inoculum instead of oiled cultures. Inoculum from an oiled culture always carries over with it a small quantity of oil, which spreads over the medium, and it is necessary to make a second transfer in order to produce a clean growth of satisfactory appearance ; this involves inconvenient delays. If our dry slants become contaminated or deteriorate we do not spend time cleaning or coaxing them, but go to our oiled stocks for fresh inoculum. Dry slant stocks are kept in duplicate, the older of the two cultures being discarded when a new sub. has been checked and put away.

Cultures prepared for oiling are planted on short slants (see p.50), a measure of economy for reducing the quantity of oil, the level of which must be at least 1 cm. above the tip of the slant.

In our early trials we autoclaved oil in 8 oz. bottles and poured the oil from these into the culture bottles. It at once became obvious that this method ensures contamination ! Air from the culture bottles displaced by oil carries out with it

air-borne spores, which adhere to the mouth of the oil bottle and are carried by oil into the next culture bottle. It seems impossible to design any kind of dispensing apparatus which could be free from this danger. Consequently we now sterilize oil in individual doses in 1 oz. McCartney bottles, which are thus used once only. Oil bottles are fitted with caps without rubber liners, and cultures which have been oiled are refitted with flamed unlined caps. This prevents the accidental wetting of liners by oil in which the rubber would dissolve with detriment to the fungi.

So far as we can tell the effect of oiling is simply to prevent desiccation. It does not stop growth—many fungi continue to grow and to sporulate after oiling, and often they grow out and into the whole volume of the oil. Respiration is not affected : we are told that oxygen is more soluble in oil than in water. After some years under oil, many fungi appear to be more vigorous than they were before oiling.

The oil method calls for no expensive or elaborate apparatus. We have not yet experimented with the lyophil process because it is known that it does not suit some fungi, and we have reason to doubt its effect on others supposedly tolerant to this drastic treatment. Moreover, lyophilized cultures would not be acceptable to many clients who obtain cultures from us. We propose, however, to conduct some trials in the near future.

Storage cabinets

Our present method of storing stocks in cabinets is the result of experience. At first we tried refrigeration, thinking this might extend the minimum period between transfers in the case of orthodox " dry " slants. We found it unsatisfactory for several reasons. At 4°C. some fungi were killed, among them common soil fungi which are frozen every winter in nature, while tropical fungi survived ! Raising the temperature to 8°C., the critical temperature for immobilizing mites, was also a failure. Many contaminations ensued through the slow growth of *Penicillium* and other moulds in the film of moisture which condensed on the bottles every time the door of the refrigerator was opened, these moulds finally growing under the caps and entering the bottles. We then switched off, but continued to use the large refrigerator as a storage cabinet at ambient air temperature. Luxurious growths of moulds then covered the wooden trays in which the bottles stood, the result of very high atmospheric humidity produced by evaporation of

water from the surface of agar in some thousands of bottles. The water vapour could not escape through the doors, made nearly airtight by gaskets, or through the metal walls. At the same time, another set of cultures, stored in a wooden bookcase with glass doors, kept in perfect condition, presumably because the doors did not fit tightly and the wooden carcase absorbed water and passed it out into the relatively dry atmosphere of the room.

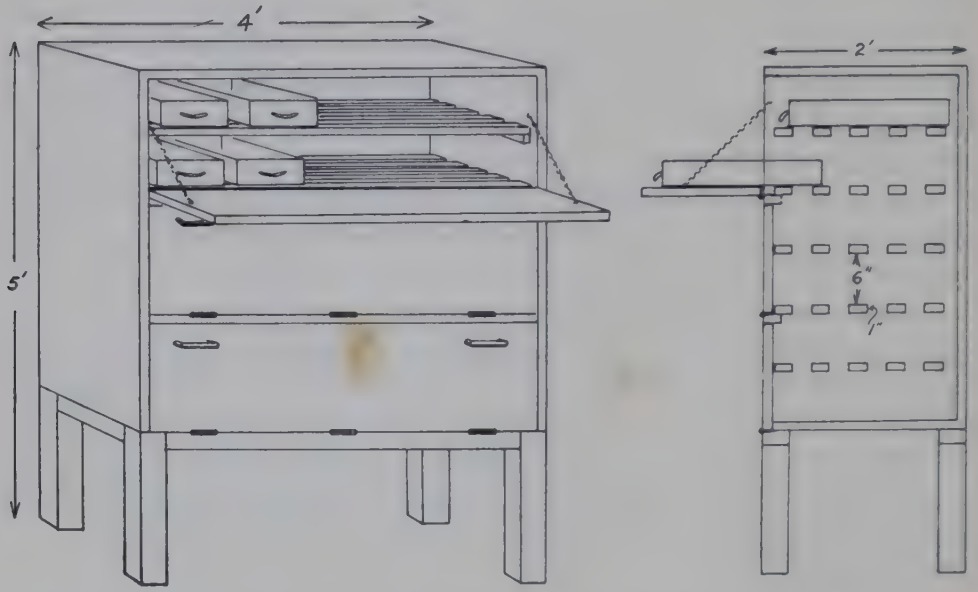

Fig. 6. Culture storage cabinet, front view and section

The cabinets which we now use, and which are entirely satisfactory, are constructed of wood, with doors which are not airtight, but which fit well enough to exclude dust and to keep up an effective concentration of paraffin vapour inside (fig. 6). The batten shelves permit circulation of air and prevent accumulation of stagnant air in corners. The drop doors, supported by chains, form when open convenient shelves on which to rest trays while cultures are being removed or replaced.

Each shelf carries up to five wooden trays, made of hardwood and measuring 19 in. × 8 in. × 3 in. Rope handles provide the most secure and comfortable grip. The trays are labelled, and the accession numbers on the caps enable cultures to be found easily and quickly. The total capacity of each cabinet is 2,880 bottles (thirty trays, each holding ninety-six bottles).

Control of mites

Mites (Acari) are the hated enemies of all mycologists. They are attracted by the odours of fungi and enter culture vessels, bringing in on their legs contaminating bacteria and moulds. They consume the growing fungi, even digging up the agar to get at submerged hyphae. They multiply very rapidly and spread quickly from an infested culture to other neighbouring cultures.

They are not a serious nuisance in normally dry and reasonably clean laboratories, but their depredations can be disastrous if walls and furniture are slightly damp, as they are in newly constructed buildings in all climates, and in all laboratories in the humid tropics. They are also able to thrive and move about freely in badly ventilated and damp incubators.

Mites are often introduced in cultures from other laboratories, or in packages of specimens, soil, etc., received for investigation, and it is therefore desirable to unpack and make a preliminary examination and selection of such material in another room. We take these precautions in the Culture Collection, where mites now give us little trouble. We had a very serious outbreak, however, resulting in the loss of about 300 isolations and giving us a great deal of trouble in plating almost all our stock, when we moved into our new building in 1955. The concrete had not dried out, and the new furniture being made of the usual unseasoned wood of to-day, was also damp.

We use successfully a simple method of excluding mites from our incubation and storage cabinets. There are many effective volatile substances which repel mites, including xylene, naphthalene, paradichlorbenzene, but all these damage fungi, inducing mutations and sterility. Pyridine repels and kills mites, but it also has a decisively repellent effect on staff. The only safe repellent which is also inoffensive is unrefined kerosene ; domestic paraffin is useless. Tractor fuel (" tractor vaporizing oil " or " Shellspark ") contains large quantities of aromatics, and is very effective. In all our cabinets and incubators we place small bottles of Shellspark fitted with split corks holding lengths of ½ in. lamp wick, an inch of which protrudes above the cork ; about one bottle per cublic foot of air space keeps up a low concentration of vapour, sufficient to exclude mites.

It is, however, essential carefully to avoid introducing

infested cultures and to keep a close watch on all cultures during incubation. Bottles and Petri dishes should not be left lying about on benches, or if this cannot be avoided, they should stand on sheets of glass smeared with vaseline.

Records

New accessions are at once entered in the Herbarium Accessions Book, and the accession numbers then allotted to them serve to identify the isolates and appear in all records kept in the Culture Collection, on labels attached to cultures, and in the published catalogue of the collection. Dried cultures are deposited in the Herbarium. The nomenclature and dispositions approved in the Herbarium are followed strictly in the Culture Collection, but obviously nomenclatural revisions cannot appear in the Catalogue until they have first been published elsewhere in proper form.

The principal records kept on paper in the Collection consist of two files of loose-leaf sheets. One of these is the History Record, with one quarto form allotted to each isolate, carrying full details of its provenance, all identity numbers attached to it before it reached the Institute, synonyms, notes on its taxonomic or industrial (biochemical) significance, references to publications concerning it, and notes on cultural characteristics, behaviour, peculiarities, etc., both before and after it was received. These sheets are filed in alphabetical order of the names of the fungi. We are now transferring all these records to the cards of a visual index system, which will greatly facilitate reference. In this system, long rows of overlapping cards can be seen at a glance, and the nuisance of fumbling with the usual type of index card is obviated. Coloured flags attached to the cards indicate reserved cultures, isolates derived from type material, authentic cultures, and those of industrial significance.

The other set of filed sheets constitutes the Culture Record. The sheets are filed in the numerical order of accession numbers, and thus, incidentally, form a cross index system with the History sheets. On these culture record forms a complete account is kept of all transfers, with dates, purpose (routine maintenance, requisition, testing, etc.), and the medium used. Remarks on behaviour are added.

We also keep files of notes on technique of all kinds, including formulae for media, strains, reagents, etc.

A useful set of records is our collection of microscope slides

of all our fungi. These show the condition in which the cultures were received, and also the full development reached after cultural trials. These slides are used for comparison with current cultures when any question of identity or deterioration arises. Permanent microscopical preparations of fungi are so important that it is worth while to describe our methods.

MICROSCOPICAL PREPARATIONS

Microscope slides

Nearly all our slides are mounts in lactophenol. The bad reputation of this medium as a permanent mountant derives from the use of traditional sealing cements, all of which react with lactophenol. It is, however, possible to make permanent preparations in lactophenol if simple precautions are taken and if an appropriate cement is used. Our lactophenol is made from the original formula : phenol cryst., 20 g. ; lactic acid, 16 ml. ; glycerol, 31 ml. ; water, 20 ml. : a stain (usually cotton blue) is incorporated. We also use unstained lactophenol for fungi which have enough colour of their own to make staining unnecessary, and then the water is omitted and the refractive index is slightly higher ; this is an excellent medium.

Lactophenol becomes brown and cotton blue stain fades if the solution is exposed to light. Amber glass bottles should therefore be used for storage, and the bench bottles should also be of brown glass. The most useful bench bottle is a 1 oz. pharmacist's dropping bottle, with a plastic screw cap fitted with a pipette and a small rubber or plastic bulb. It is an advantage to replace the standard pipette with a finer one drawn from glass tubing. These bottles are cheap and better than any piece of specially made laboratory glassware.

Until very recently, cotton blue was used almost exclusively at a final concentration of 0·1%, corresponding to a concentration of 0·5% in the water used in making up the lactophenol. If it is occasionally found necessary to reduce the concentration of the stain, this is done by diluting with undyed lactophenol. Though it is a very useful stain for general routine purposes, cotton blue shares with nearly all other stains the defect of total failure to stain fungus cell walls. We are now making increasing use of trypan blue, for which Boedijn (1956) has claimed the property of staining cell walls. Our experience is that it stains the inner layer(s), though not the outer, but even this

limited effect is most valuable. It is also to some extent selective, giving better pictures of cell contents than cotton blue.

Boedijn describes two ways of using the stain : (i) a rapid method, the stain being applied under the cover glass at a concentration of up to 0·5% in 40% alcohol, after which the stain is withdrawn with blotting paper and replaced by undyed lactophenol, and (ii) a slow method, in which the stain is used at similar concentration in lactophenol, which is replaced by plain lactophenol as in the alternative method. The process of replacement is a messy one, which makes permanent mounting troublesome, and it does not appear to be essential, for trypan blue can be used in the same way as cotton blue, with a single operation, if the concentration of the stain is not too great. Trypan blue stains rather slowly, and a preparation which has a perfect appearance when freshly made continues to absorb the stain for several hours. A 0·2% solution of trypan blue in lactophenol is usually satisfactory. However, there are cases when transference to plain lactophenol may be an advantage. When the material will stand the extra manipulation, that is, when there is no danger of delicate parts of sporophores becoming detached, very satisfactory mounts may be obtained by first staining in bulk, using a large pool of stain on a slide or on the undisturbed culture on a plate, selecting suitable pieces, and transferring these to plain lactophenol. When the mount is rather thick a coloured medium is obviously unsatisfactory. Examples of thick mounts are small fruit bodies which we do not wish to crush, and large zygospores (*Phycomyces* and *Syzygites*) ; these are most conveniently prepared in cavity slides with small cavities up to 5 or 6 mm. in diameter.

When the material to be mounted consists of conidiophores bearing dry spores, it may be difficult to wet the spores and to avoid including quantities of air. In such cases a small tuft of the material, while still on the needle, can be wetted by touching it with a rod dipped in ethyl acetate, after which it is placed in lactophenol on the slide and teased out. The ethyl acetate quickly evaporates when the slide is warmed. A minute spot of lactophenol on the centre of the cover prevents bubbles from forming when the cover is applied. For temporary mounts teepol or some other fluid detergent may be mixed with the lactophenol, but the effect of detergents on permanence of preparations is not at present known.

Sealing

All resins and gums (with the exception of some samples of dammar) dissolve in phenol ; they are therefore useless as the bases of cements for sealing lactophenol mounts. Asphalte appears to resist phenol, but it causes stains to fade. We have made exhaustive trials of other cements, too, and have found all to be unsatisfactory for one reason or another except nail lacquer, which the experience of about ten years shows to be quite effective as a seal, and which does not affect stains. Nail lacquer is designed to adhere firmly to finger nails, which are slightly greasy, without cracking, and it is therefore not brittle. These qualities are precisely what we want in a microscopical cement. Its composition and compounding are by no means simple, and it is best to buy it ready made. It may be either colourless or coloured, the advantage of colour being that one can see clearly where it is being laid on (see p.32). " Opaque " lacquers, containing solid sediments, must be avoided : they do not " run on " smoothly. Transparent lacquers, whether coloured or not, run on very freely and smoothly indeed when applied with a brush (No. 3 sable), either by hand or on a turn-table. For routine slides we use $\frac{5}{8}$ in. square covers, which are quickly sealed by hand and leave sufficient room round them on the slide to allow adequate bands of cement to be put on.

Much time and trouble may be saved by preventing the cement brush from drying between use by suspending it in acetone vapour in a bottle, containing a little acetone and fitted with a bored cork which fits the brush handle loosely.

Several coats of cement must be applied to ensure against leakage or drying of the lactophenol, each coat being allowed to harden before the next is laid on. The first coat should be of colourless lacquer, which is not unsightly if a little runs under the cover, as occasionally happens. All the succeeding coats may be coloured. After the first two coats have been applied, forming a barrier between the lactophenol and succeeding coats, the preparations may be finished with any other preferred cement.

It is most desirable that valuable preparations should be protected as well as possible from accidental damage. Mounts finished with nail lacquer are as robust as those sealed by any of the usual cements, and they will stand handling with ordinary care, but it seems likely that we may find still stronger sealing media.

The edges of the cover glass and the surrounding part of the slide must of course be quite dry and free from exuded lactophenol if the seal is to be effective. Sometimes this is virtually impossible, as, for example, when material grown on the slide is being mounted, or when cavity slides are being used, for then it is necessary deliberately to overfill the cavity and to eliminate excess medium by pressure round the edges of the cover (but never in its centre). In such cases, effective sealing may be ensured by the following method. When there is a great deal of exuded lactophenol, most of it should be removed with blotting paper or filter paper. A piece of the paper is laid over the slide, and prevented from moving by firm pressure over one end of the slide ; gentle pressure is then applied to the edges of the cover with a finger of the free hand. If the exudation is very slight and localized, this is unnecessary. A very narrow band of colourless lacquer is then put on and allowed to harden. This does not form a seal, but adheres sufficiently well to anchor the cover glass during the next operation, which is to wash the slide under the tap, thus removing the last traces of lactophenol. Finally the slide is rinsed in distilled water, the moisture removed with the edge of a piece of filter paper, and the slide set aside to dry. The seal can then be completed in the usual way by applying broad bands of cement.

Recent experiments have shown that the use of a suitable water-repellent silicone such as " repelcote " may reinforce permanence by preventing ullage or creeping of the liquid mountant under the cement. Repelcote is a 2% v/v solution of dimethyldichlorsilane in carbon tetrachloride, distributed by Messrs. Hopkin and Williams Ltd., of Chadwell Heath, Essex. It is applied before mounting begins to the edges of the cover glass and to the surrounding parts of the slide. It evaporates instantly and its effect cannot be removed except by chromic acid. Repeated scrubbing with concentrated detergents failed to have any effect in our trials. Cements adhere firmly to treated glass. Care must be taken to avoid the contamination of other glassware by the silicone, for pipettes, other measuring vessels, rods which we want to be wettable, etc., are rendered useless by it.

Araldite Cements

Nail lacquer, though entirely satisfactory in all other

respects, is, like all the traditional sealing cements, susceptible to mechanical damage. Progress in the development of industrial synthetic resins has made it possible to strengthen the seals of lactophenol preparations, which can now be made as robust as balsam mounts, but devoid of stickiness. This has been demonstrated by recent tests of two " cold "—setting epoxy resins, Araldite X.83/4 and Araldite D, manufactured by CIBA (A.R.L.) Ltd., of Duxford, Cambridge.

In both cases, the resins and their appropriate hardeners are supplied as separate, syrupy liquids, which must be mixed in the correct proportions before use and can then be laid on with a brush. When a turntable is used, it must be started slowly to avoid drawing strings of cement across the cover glass. The resins " cure " slowly at air temperature (24 hrs. at 20° C.), but much more quickly at higher temperautres, e.g., in about 8 hours at 40° C., which will not harm lactophenol mounts. They then adhere very strongly to the glass slide and cover, and cannot be detached without using metal tools and considerable force. Araldite D sets harder than X.83/4, but does not run off the brush quite so easily, and its hardener may cause skin irritation and must be handled with care. X.83/4 remains slightly resilient, but is extremely tough, and its hardener is harmless ; it runs from the brush more easily than does D.

Brushes and glassware must be cleaned with acetone before the resin hardens. This is not troublesome if simple apparatus is used for mixing. The lower part of a bijou culture bottle, cut off with a diamond, forms a useful container. The thick fluids can be removed from the original pots with a glass rod, from which they can be dropped into the mixing vessel, and the proportions can be judged by eye before stirring. These are, for X.83/4, two vol. of resin to one of hardener, for D, ten to one.

To serve as a barrier between the lactophenol and the resin, and also to prevent moving the cover when applying the viscous resin, two preliminary layers of nail lacquer are applied, the first of these, or both, being colourless. These bands of lacquer should be as narrow as possible. A single, broad and very thick band of Araldite is then run on, overlapping the lacquer to provide good anchorage on the slide and cover.

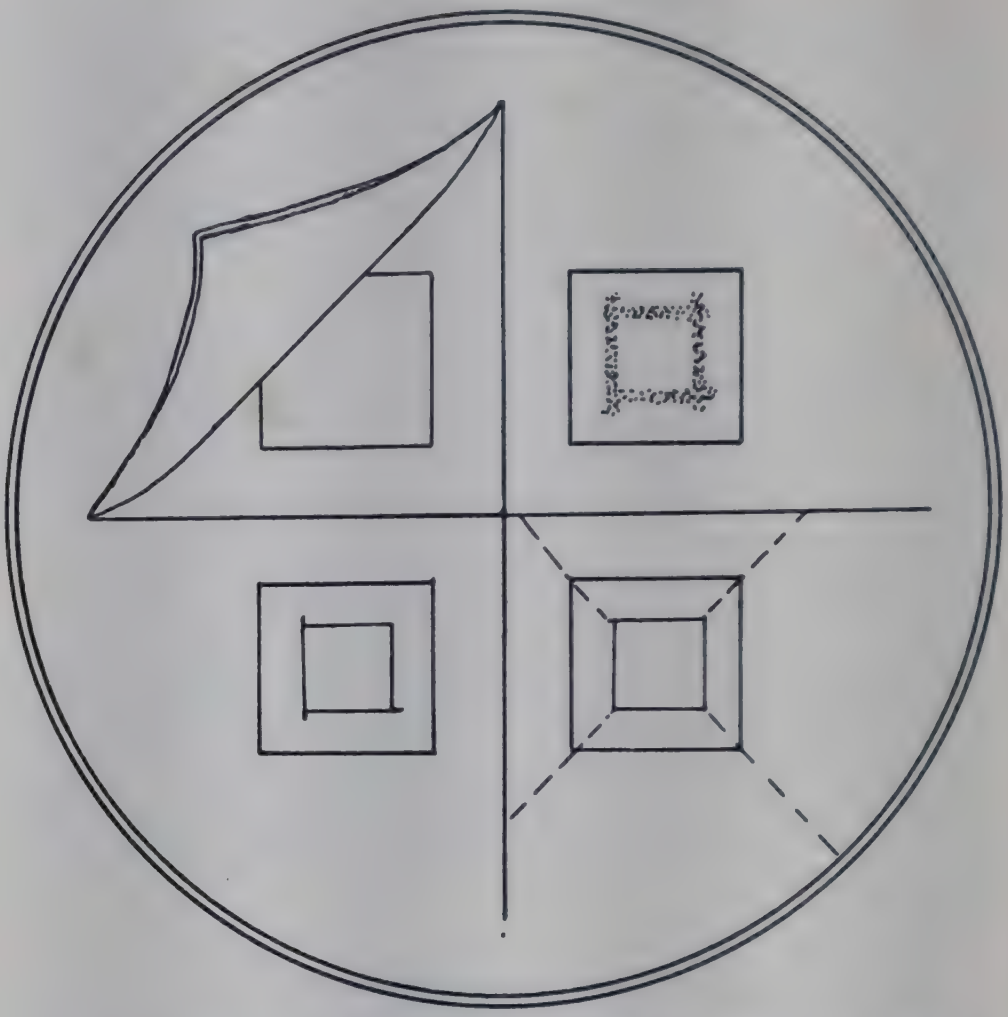

Fig. 7. Petri dish with agar plate for cover glass cultures. *Top left*, agar flap raised and cover inserted. *Top right*, grease pencil square marked on bottom of dish. *Bottom left*, square hole cut through agar above middle of cover. *Bottom right*, broken lines show slits cut in agar to permit removal of agar and then of cover

Cover-glass cultures

Visitors to the Institute are probably familiar with the method of slide culture used in the Herbarium to secure preparations showing undisturbed growth and sporulation. In the Culture Collection we use a somewhat different technique, designed to obtain growth on the centre of the cover glass instead of near its edges. A plate of suitable medium is poured and allowed to set. Two diametrical slits, at right angles, are then cut in the agar with a flamed scalpel (fig. 7). The tri-

angular lips formed by the slits are lifted, one by one, and a flamed cover glass is inserted under each lip, which is then replaced. The dish is inverted, and the position of the covers, seen through the glass of the dish, is then marked with grease pencil, small squares of $\frac{1}{4}$ in. or $\frac{5}{16}$ in. side being drawn in the middle of the covers. These blue squares show through the agar when the dish is again turned, and enable corresponding pieces of agar to be cut out and removed. The medium is then inoculated and the dish is incubated. Growth eventually extends over the exposed area of each cover, and can be examined with the binocular magnifier. When it has proceeded far enough the covers are removed by cutting away the surrounding agar (severing the hyphae if necessary) and are mounted in the usual way. The method of dealing with wet covers, described above, should be employed when sealing the mounts.

" Micro-jars "

Collections of fungi preserved for taxonomic purposes must be mainly in the form of dried herbarium material. Sometimes, however, it is desirable to keep specimens in some way which maintains their fresh appearance, and this usually means storing them in a fluid. Alcohol, with or without formalin or other added fixative, tends to evaporate in spite of efforts to seal the containers, and the care of such a collection entails more labour and greater danger of loss than most institutions can afford. Glycerol, mixed with an equal volume of water, applied after preliminary fixation in alcohol or formalin-alcohol (which dissolves entangled air as well as fixing the material) is an excellent preservative free from the disadvantages of alcohol. When it is prepared it should be heated to expel dissolved air, which otherwise will come out and form myriads of small bubbles which cling to the material ; but it should be heated only until it approaches boiling point, and then cooled. Material in bulk can be stored in almost any kind of specimen tube or jar.

It is useful, in addition, to preserve selected portions of the material showing general habit and appearance in a form convenient for examination at any time under the binocular magnifier, thus supplementing the information provided by microscope slides. Formerly such relatively bulky specimens were put up in deep cells cemented to microscope slides, but these preparations are not reliably permanent, the pressure generated by fluctuating temperature causing the seals to

break down sooner or later. This kind of material would be regarded better as small museum specimens rather than microscopical specimens, to be kept in something like a museum jar.

Several years ago the writer (1947, 1953) devized a " micro-jar " container, intended originally for insect dissections, but equally useful for microfungi which form characteristic fruit bodies, or pathological specimens with features profitably examined at low magnification (*ca* × 15 to × 20 d.).

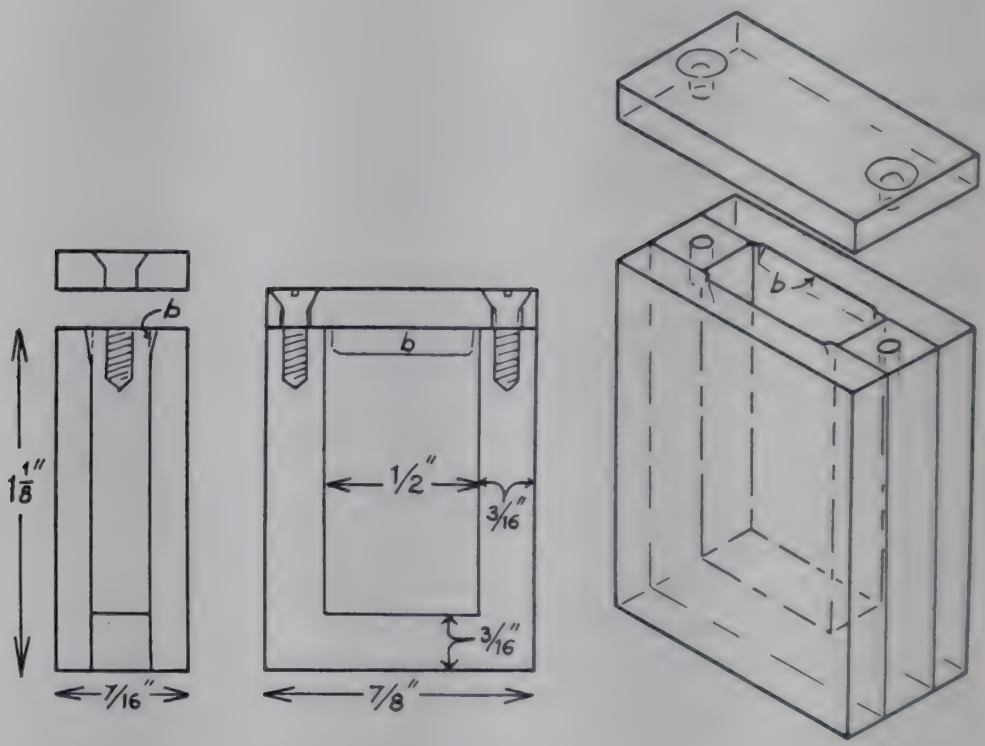

Fig. 8. " Micro-jars," constructional details

These " micro-jars " are easily made from perspex sheet $\frac{1}{8}$ in. and $\frac{3}{16}$ in. thick, the component parts being cut out with a piercing saw with metal-cutting blades. A suitable form is illustrated (fig. 8), the dimensions being shown. It consists of two rectangular panes cemented to a U-shaped middle piece with a solution of perspex in chloroform, and a lid. The assembled parts are screwed in a vice or clamp and left overnight to allow the cement to harden. The rough edges of the jar are filed flat, then rubbed down on the finest glasspaper, laid

on a piece of plate glass ; finally the whole is polished with " Brasso," using a cloth laid on plate glass. The mouth of the jar should be very carefully finished, to make a good joint with the lid. Bubble traps are small areas filed away (as at " b " in the drawings) to hold bubbles and prevent them from wandering across the specimen when the jar is laid flat in the magnifier stage. Holes are drilled and tapped to receive 6BA screws, with which the lid is secured.

The specimen may be a piece of leaf or twig, or agar cut from a culture. It should not be free to float about, but should be cut so that it fits the inside of the jar. After soaking in alcohol until air bubbles have gone the material is transferred to a watch glass of the diluted glycerol, and left there for a day or two. In the meantime the jar is filled with alcohol to remove air clinging to its inner corners. When the specimen is ready, the jar is emptied and its lip dried and smeared with rubber grease (as used for burette cocks). The jar is then filled to the brim with air-free, 50% glycerol, and the specimen is inserted. The jar should now be over-full, with liquid standing up above the mouth. The lid, also greased, is put on and pressed down, squeezing out the excess liquid, the screws are inserted and screwed up tightly. After rinsing under the tap and drying, a label can be stuck to one side of the jar with " U-Hu " or some similar adhesive which will adhere to plastics, and when this has hardened the label may be protected by painting it with colourless nail lacquer.

It is best to store the jars in the upright position, so that any bubbles will stay at the top of the fluid, and they should never be turned upside down or bubbles may cling to the specimen and be difficult to dislodge. If the lid fits well, there will be no ullage. In the unlikely event of excessive leakage, and replacement of too much fluid by air, it is a simple matter to remove the lid and " top up."

The relatively thick panes are an advantage : dust particles or faint scratches on the outer surface of the jar are out of focus when the magnifier is focused on the specimen.

Other forms of container may be preferred by some readers. The back pane can, for example, be made the size of a microscope slide. However, experiments with other models have led the writer to the conclusion that the form described here is the most satisfactory.

RELATIONS WITH PUBLIC

Issue of cultures

The Catalogue of the Culture Collection contains all the details necessary for clearly identifying particular isolates. Such details are of great importance in taxonomic research, and also in industry where particular strains with special biochemical properties are usually required. The data given include the Institute's accession number and all other identifying numbers previously given to the isolation by those workers who have studied it. The host or substratum from which the isolate was derived, the names of previous owners, with dates and notes on special properties are also recorded. Two categories are of particular interest to taxonomists : cultures derived from type material, marked " (T)," and cultures marked " (A) " which have been identified by the authors of the binomial which they bear. It will be noticed that we avoid the term " Type Culture." We have cultures *derived* from type material (" ex Type Coll."), but the term " type culture " can only be applied properly to the actual culture on which a species has been erected, and not to its descendants.

New editions of the catalogue are issued every three years, and supplements, showing additions, deletions, and changes of disposition, every six months.

The routine clerical work associated with the supply of cultures need not be described. When cultures are ready for dispatch after being checked they are packed in specially made balsa wood blocks (Solarbo Ltd., Lancing, Sussex), which are very light in weight and surprisingly durable. We ask for their return when we supply cultures at nominal prices to research and educational institutions, and these blocks make several journeys through the post before they are discarded.

We are careful to comply with the quarantine regulations of other countries. The quarantine authorities of Canada and the United States require their nationals to obtain permits to import cultures, and special tags are issued for attachment to packages ; without these tags entry may be refused, and we do not dispatch cultures until they are received.

Advisory work

Mycologists working in the Culture Collection take part in the identification service of the Institute, " moulds," being their special province. Industrial problems associated with the

moulding of stored products, of manufactured goods, and of equipment are referred to us. We receive a great many letters and visitors asking for advice on problems connected with cultural methods and with the handling of cultres in industrial testing and manufacture. We also give much assistance to teachers in schools and colleges, many of whom wish to extend teaching beyond the range of stereotyped syllabuses to stir their pupils' interest. We have devized simplified methods of culture and suggest to them interesting demonstrations of fungi, of which we have a useful number suitable for such purposes.

DONATION OF CULTURES

The Culture Collection depends very largely on isolates received from those mycologists and plant pathologists who correspond with the Institute. Cultures of newly described taxa of strains of industrial value are specially welcome, but new and vigorous isolations of well-known plant pathogens, or of fungi of interest in education, such as complementary pairs of heterothallic moulds or forms which show remarkable biological phenomena, are also desired. Free exchanges are given for all acceptable cultures. Cultures should be accompanied by full details as to source, locality, etc., and we are glad to have in addition dry herbarium specimens of the material from which the isolates have been derived.

REFERENCES

Boedijn, K. B. (1956). *Stain Technol.*, **31** : 115
Dade, H. A. (1937). *Trans. Brit. mycol. Soc.*, **21** : 16—28
Dade, H. A. (1947). *J. Quekett micr. Cl.*, Ser. 4, **2** : 199—202
Dade, H. A. (1953). ibid., 509—510
Hansen, H. N. & Snyder, W. C. (1947). *Phytopathology*, **37** : 369—371
Heald, F. D. & Pool, V. W. (1909). *Rep. Nebraska agric. Exp. Sta*, 22 : 130—132
Langeron, M. (1945). Précis de Mycologie. Paris, Masson & Cie.
McCormick, F. A. (1925). *Bull. Conn. Exp. Sta.* 269
Mason, E. W. (1933). Annotated Account of Fungi received at the Imperial Mycological Institute, List II, fasc. 2, 35—39. Kew, Commonwealth Mycological Institute, 1933
Molliard, M. (1903). *C.R. Acad. Sci. Paris*, **136** : 899—901
Petch, T. (1925). *Trans. Brit. mycol. Soc.*, **10** : 166—171
Wernham, C. C. (1946). *Mycologia* **38** : 691

THE TREATMENT OF IMPORTANT PATHOGENIC PHYCOMYCETES

GRACE M. WATERHOUSE

Obligate parasites among the phycomycetes receive similar treatment to those in other groups. Plant specimens submitted should be pressed so that the leaves are spread out flat and not crumpled. Oospores, if not found in the tissues near the lesions bearing the asexual state, should be searched for elsewhere. For example, oospores of *Albugo ipomoeae-panduratae* are usually confined to stems and fruits and are not present in the leaves bearing pustules ; those of *Peronospora viciae* are often found in the stem tissues bordering the pith. Consequently, other parts of the plant, as well as obviously infected leaves, should be included in the collection. Dark oospores can often be seen in whole specimens under the binocular. If oospores have been found, the plant portion containing them should be clearly indicated to save the patient (or impatient) Mycologist from toiling through a mass of sterile material. Hand sections warmed in lactophenol or caustic alkali will be sufficiently clear to enable the oospores to be seen ; they can be teased out of such tissue if it is thick or opaque. Sections are also useful for examining pustules (*Albugo*, *Synchytrium*, and *Physoderma*).

The washing method

Most species of *Pythium* and *Phytophthora* are root inhabiting, and such fungi, often the cause of root rotting, are becoming increasingly important. For the selection and isolation of fungi which may be responsible for root deterioration the following method has been found useful. The whole root system is spread out in a single Petri dish and covered with distilled water. Where the root sytem is too large for one dish that can be conveniently accommodated on the microscope stage representative portions about 1 in. long are cut off and distributed in distilled water in dishes. If enough material is available, two sets can be established, one with tap water-washed roots and one with surface sterilized (calcium hypochlorite) roots. Fungal hyphae soon grow out into the water. A rapid survey of the dish or dishes indicates which are the predominant types, and therefore likely to be the pathogen responsible. Representative portions bearing such hyphae (those of

oomycetes I can quickly recognize, and doubtless specialists in other groups will be able to spot familiar types) are cut off and transferred to fresh dishes. Directly sporangia appear, small boiled or propylene oxide-sterilized seeds (hemp, poppy, petunia, antirrhinum) are added to "pick up" released zoospores. These seeds are removed to fresh dishes as soon as the zoospores are likely to have settled down; they usually bear a single fungus species which can be cultured easily. If sporangia are not formed, or even if they are, small root pieces (1 mm.) bearing recognized hyphae are plated on plain water agar. This medium not only slows down growth considerably but reduces branching and makes easy the cutting out of single hyphae for transfer. If the agar surface is allowed to dry before inoculation bacteria are usually confined around the inoculum, and hyphae soon grow out beyond them, though if bacteria are troublesome (e.g. at higher temperatures), antibacterial substances (rose bengal, aureomycin, acid) may be added to the agar.

In the course of examining large numbers of root specimens septate fungi have often been seen sporulating on submerged hyphae. It appears, therefore, that this method might well be used for *Fusarium*, *Alternaria*, *Cephalosporium*, etc.

[In the tropics, bacteria and species of *Fusarium*, especially, are sometimes very persistent and depress the growth of the phycomycete so that recognisable sporangia are not produced. In order to eradicate these contaminants small pieces about $\frac{1}{8}$ in. cube should be cut from selected tissues, placed in a small perforated vessel made buoyant by a large cork, and floated on running water overnight, or they may be placed in a small muslin bag and similarly washed. In the morning the cubes are transferred to sterile, distilled water in 9 cm. Petri dishes and placed in bright light near a window. After twenty-four hours, only the most stubborn fungi fail to produce sporangia and, usually, zoospores an hour or two later.

It is supposed that during the washing process cell nutrients which promote the growth of saprophytic fungi and bacteria are removed and the phycomycete is able to outgrow its antagonists in plain water. J.C.F.H.]

Cultures

For oomycetes which can be isolated on agar (mostly *Pythium*, *Phytophthora*) a culture is essential for the identification of most spp.; only a very few with outstanding characters,

such as *Phytophthora infestans*, can be identified from the host. The media which give the best growth of *Pythium* and *Phytophthora* are oat, cornmeal, and malt agars : the least suitable, in fact sometimes harmful, is potato dextrose agar and should be avoided. The medium used should *always* be stated.

Some of those species with aquatic tendencies need rather different treatment from the members of other fungus groups in order to secure the different reproductive organs necessary for identification ; often these may not be produced under the comparatively arid conditions of agar culture in the laboratory. Details of the procedures which may be used with success are ably and admirably described by Emerson (*Mycologia*, 50 (1958), p. 589) in a paper which every student of this group should have near at hand. The method is one which might well be used even for non-aquatic groups since it induces aerial fungi, also, to grow and fructify well. Briefly, the essence of this method is (1) for sporangia, to grow the fungus on a natural substratum (boiled grass blades appear to be successful with most species) in an autoclaved mixture of filtered pond and distilled water (1 to 2), tested to make sure that it is non-toxic by means of a standard strain producing zoospores readily under normal circumstances ; (2) for sex organs, boiled hemp (or other small) seeds placed in contact with a culture to acquire inoculum are then transferred to " water." For species of *Phytophthora* I have found Petri's solution very satisfactory over the years and it is a standby if local ponds are distant or toxic.

The temperature at which the cultures are to be maintained will be determined with regard to the latitude of origin of the strain, those from cool or temperate areas or seasons being kept at lower temperatures than those from the tropics or subtropics (incubation should be tried if cultures will not perform at laboratory temperature). If method (2) fails with *Phytophthora* spp. then they should be grown in dual culture with strains known to stimulate oospore production, the strain being selected on the basis of the tentative identification of the unknown from the sporangial state. The pairings which are known to stimulate oospore formation are *cinnamomi : cryptogea, cinnamomi : palmivora, cambivora : parasitica, parasitica* " rubber " : *parasitica* " cacao," *palmivora : palmivora, infestans : infestans*, and possibly others.

Cultures are stored under mineral oil with cigarette paper

barriers over the tube mouths, against mites and dust. We have found this an excellent method for *Pythium* and *Phytophthora*, our oldest culture under oil (13 years) is still viable.

Identification of *Pythium* and *Phytophthora* is not easy and though I do not subscribe to Fitzpatricks's statement that for *Phytophthora* it is " difficult, if not impossible " it would be greatly facilitated by a " world " key, which is badly needed. The importance of this genus may be gauged by the coverage in the *Review of Applied Mycology* where the index entries under *Phytophthora* equal those under *Puccinia*, and those for *Phytophthora infestans* exceed those for *Botrytis cinerea*.

BACTERIA AND THE HERBARIUM

A. C. Hayward

Introduction

A bacteriological laboratory was set up during 1959 to provide a service to Commonwealth countries for the identification of bacteria of importance in plant pathology. The laboratory and library facilities required to carry out this work effectively are substantially different from those needed for the identification of fungi, primarily because biochemical and physiological techniques have found more application in the systematic study of bacteria than of fungi. Essential equipment is being obtained, and with further improvements a regular identification service is visualized for the near future. In the meantime taxonomic work is being commenced.

Despatch of specimens and cultures

Ideally, both freshly collected specimens and cultures should be sent for examination. Cultures should be in small tubes (e.g. $3 \times 0{\cdot}6$ in.), containing a 1 to $1\frac{1}{2}$ in. column of nutrient agar (supplemented with 0·5 to 1% sucrose for cultivating *Xanthomonas* spp. and *Pseudomonas solanacearum*) and inoculated by stab. The medium should contain 2% agar : 1 to 1·5% agar slants are usually ruptured in transit, which increases the risk of contamination. Tubes should be dispatched in balsa wood postal blocks, or, alternatively, wrapped in cotton wool and corrugated cardboard and sent in strong cardboard boxes. All plant material and cultures should be addressed to the Director, C.M.I.

Pieces of diseased material, shoots, roots, and twigs should be cut into short (3 to 4 in.) lengths. Roots should always be

free from soil. They should be rinsed well in 0·35% sodium hypochlorite solution for ¼ to ½ hour to remove surface moulds, washed well in clean water, then partially dried and packed in cellophane, in preference to polythene, with the end open. Polythene retains too much moisture. Packages should be wrapped in brown paper and sent by air as soon as possible after collection.

Isolations from diseased material

The method used will depend on the material provided. In the case of " striped " leaves of sugar cane, the following technique may be used. Cut out several parts of the leaf bearing stripes, dip in alcohol, then immerse in 1/1000 mercuric chloride solution for 2 minutes. Wash thoroughly by transferring to sterile tubes of distilled water two or three times before placing on an agar slope.

Isolations from leaf spots are effected by cutting out the lesion with sterile scissors and forceps and transferring to a few ml. of sterile distilled water in a Petri dish. The tissue is then teased apart into small fragments using sterile seekers and left at room temperature for the bacteria to diffuse out. Loopfuls of suspension are streaked on to several different agar media (Dowson, 1957) after 4 to 8 hours and again after 18 to 24 hours. The temperature of incubation of the isolation plates is an important factor; 23 to 25° C. is necessary where plant pathogenic corynebacteria are expected and 28 to 30° C. for other bacteria. Isolation plates are incubated for at least six days before being discarded.

The lengthy process of colony differentiation and purification then follows. Colony forms are differentiated by examination by transmitted and reflected light and under the dissecting microscope. Each colony type is obtained in pure culture and examined morphologically with a few simple techniques before detailed examination.

Isolations from stems and shoots are carried out as described by Dowson (1957), the material is teased apart, and inoculations made as described above.

Systematic examination

Bacteria are identified primarily by studying their morphology and behaviour in culture at different temperatures and on different media.

The study of the morphology and cytology of bacteria is of very great importance in identification, but morphological

differences, in the large and important group of aerobic, Gram-negative, rod-shaped bacteria, for example, may be rather subtle and difficult to define precisely without the use of methods too elaborate for an identification service. It is in the study of the physiology and biochemistry of bacteria that precise criteria are to be found, which serve to classify bacteria of closely similar morphology. Serological methods and bacteriophage sensitivity testing should be more widely used for plant pathogenic bacteria.

It is regrettable that most bacteria of importance in plant bacteriology are inadequately described by any criteria. There has been a general lack of comparative study of bacteria of importance in different applied sciences. It is the aim of this laboratory to remedy some of these deficiencies.

Bacteria shown by systematic examination to be close to published descriptions or, when available, to cultures of pathogens from the same host should be inoculated back into the host in order to reproduce disease symptoms, and re-isolated in pure culture, thus fulfilling Koch's postulates.

Maintenance and preservation of cultures

A collection of bacteria of diverse plant origin is now being built up in this laboratory. They are maintained under oil or in the freeze-dried state, or in sterile soil in the case of *Streptomyces* spp.; they serve a purpose equivalent to that of the herbarium specimen for the mycologist. They can be readily reactivated in culture for side by side comparison with related bacteria sent for identification, and if proved to be plant pathogens are sent to the National Collection of Plant Pathogenic Bacteria at the Ministry of Agriculture Plant Pathology Laboratory, Harpenden.

REFERENCE

Dowson, W. J. (1957). Plant Disease Due to Bacteria. Cambridge University Press.

COLLECTING FUNGI

C. Booth

Before any student of mycology can take a real interest in taxonomy, or appreciate its problems he must have a fairly wide knowledge of the various groups of fungi to provide a background on which to base his ideas.

The best way to acquire this knowledge is for him to get to know the common species of fungi growing in his neighbourhood, and to do this he must collect them. Systematic collecting contributes far more to mycological knowledge than is generally appreciated and for a mycologist it is important to know fungi in relation to their surroundings and to develop a collector's eye. Too many students think that to collect fungi without naming them is time wasted. This is not true, especially for beginners.

The important unit in mycology is the species and any student with a good eye for collecting and for detail, and a good memory for macro- and microscopic details can learn the species in his local flora. If collecting is pursued conscientiously and over as great a part of the year as possible the common species become known and, furthermore, recognizable in their various stages of development.

How to collect

When making collections several tools are useful. These include a strong knife, secateurs, a small saw, a razor blade in holder, a hand lens (approx. $\times 10$), and suitable envelopes or tins for the specimens. These suffice for general collecting, but if specialised habitats are being investigated, such as ponds and streams, other tools and containers are often required. When making collections care should be taken to name the host plant or other substratum accurately. Each specimen as collected is placed in a separate temporary newspaper envelope until fully dried and the name of the host, the locality, and the date of collection written on the envelope.

Abundant gatherings should be made of each collection. There is no evidence that rare species will disappear by over collecting as is sometimes the case with flowering plants. With microfungi, especially pyrenomycetes, the perithecial stromata persist long after the spores have been discharged and one can easily return from a collecting trip carrying so much firewood. To avoid this, and to make sure that the fungus is still living it is a good practice to slice across the edge of a stroma

or across the top of one or two perithecia. If the locules are then examined with a hand lens they will, if collected under moist conditions, be seen to be filled with mucilage, or if conditions are dry, then the inner wall of the locule will be smooth and shining. On the other hand, if the fungus is dead the inner wall of the locule appears dull and mucilage is absent. Soon after collecting, the specimens should be reduced to a size suitable for disposal in the herbarium, herbaceous material carefully pressed, and then thoroughly dried in a warm, well ventilated room.

Identifying fungi

When these collections have been divided into species, names are important when the student wishes to publish a list of his species, to communicate with other mycologists, or to check his observations against published descriptions. If he has to rely on published papers to name all the common species initial progress will be both slow and difficult. The early stages of acquiring knowledge of the common fungi can, however, in Europe at least, be passed through both quickly and pleasantly, for most countries and most English counties have local natural history societies and sometimes a mycological society. By joining in excursions arranged by these societies a great deal of information, including the names of many common species, can be quickly acquired. Almost all mycologists have received encouragement, stimulation, and information on such occasions.

The young mycologist learning common species in Europe is learning the same species that were collected by the earliest mycologists, such as Tode, Persoon, Link, and Fries, and hence the species on which many of the important genera in the present day classification are based. Once this background has been acquired it is much easier to use keys and to follow published descriptions. Thus, one can approach the identification of exotic species, particularly tropical collections, and appreciate in which genus or sometimes one of several genera a fungus would have been placed if previously described.

Life Histories

If interest is confined to one country, more specialised collecting can be profitably undertaken. Distinct geographical habitats such as salt-marshes, acid and alkaline woodlands, heaths, and moors should be visited. Irrespective of seasonal variations, it soon becomes apparent that similar niches in these

varying habitats are often occupied by different species of fungi and that the abundance or otherwise of fungal fructifications varies greatly. Thus, near towns or other regions of atmospheric pollution comparatively few fructifications are found. This does not mean that fungi do not occur ; there is abundant evidence of fungal decay, but they do not readily produce fructifications.

Fungi are often classed as parasitic or saprophytic depending upon whether they attack the living or the dead. In practice this distinction is by no means clear. There are parasitic fungi which do not form fructifications until the host is dead. Others, which produce leaf spots or anthracnose, will form conidia on these lesions whilst the host is still living, and then after the plant dies will produce resting bodies, such as perithecia or chlamydospores, on the dead plant tissue. Thus, if the life history of the fungus is unknown the resting states may be classed as saprophytic fungi. There are also many fungi which have an apparent symbiotic relationship with their host and do not produce fructifications until the fungus-host relationship is upset by adverse conditions or injury to the latter.

All these factors may be classed under the relationship of fungi to their surroundings and much information regarding these relations is gained by the observant collector.

COLLECTING FUNGI IN THE TROPICS

F. C. Deighton

A new-comer to the tropics, particularly the wet tropics, may well bear in mind the following points.

(a) The tropical flora is far less well-known than that of more temperate regions where more collecting has been done ; and this applies not only to fungi and other cryptogams but also to phanerogams. A large number of quite common tropical fungi are not adequately known or are represented in herbaria by relatively few collections. This often applies to " well-known," economic, plant pathogens which are often identified locally by the Plant Pathologist, but of which no specimens are kept for future reference. The lack of material for examination is a serious handicap to anyone wishing to study variation in a fungus species or to check a recently published " new variety "

or " new species " which may seem to him doubtfully distinct. There is also still a large number of fungus species (particularly in the tropics) that are as yet undescribed, some of which may be quite common in one particular area but have escaped collection. It must be remembered that the taxonomy of fungi is under constant revision and that further gatherings of one of the better known species may show that more than the one taxon originally described is involved, or that two or more " species " (each possibly represented by one single collection) are in reality only extreme variants of one species.

(b) Similarly, the phanerogamic flora is likely to be imperfectly known, and therefore (if there is the slightest doubt) a recognisable specimen of the host plant of a fungus—if possible, a portion of the stem with flowers or fruit as well as leaves attached—should be collected at the same time. It must be remembered that the remainder of the flora is under constant revision just as much as is the fungus flora.

(c) In the tropics, and especially in the wet tropical forests, saprophytic or weakly parasitic fungi are often not so specifically restricted to one host plant as they may be in more temperate regions. This may be due to the occurrence, in tropical forests, of a multitude of phanerogams, belonging to related or widely different families, with much the same growth form and environmental requirements and providing a fundamentally similar matrix for a fungus. Continued collecting may show that a saprophyte (or sometimes a parasite) may occur on a wide range of host plants, but with a preference for some. A preference may be shown for dead branchlets of soft-wooded trees, or for one tree species, while in other cases no such preference is to be observed. Dead leaf-stalks and trunks of palms have a fungus flora of their own, though some of the palmicolous fungi may also occur on other substrata.

(d) The leaves of many tropical, evergreen phanerogams, in addition to various parasitic fungi, are often covered with a number of species of fungi or lichens which are entirely superficial and live perhaps on the exudate from the leaves or possibly on nutriments deposited on the leaves by wind and rain. These fungi (e.g., the Micropeltaceae) are often not specific to any one host plant though they may show a preference for certain types of leaf surface. It is in some cases difficult to distinguish a foliicolous lichen from a closely related non-lichenized fungus.

(e) It is common to find more than one fungus species growing together on other substrata in the tropics. Several saprophytic species of *Nectria* may occur mixed on one small piece of cacao pod (" husk "), and in addition there may occur, mixed with them or overgrowing them, more than one species of hyphomycete other than conidial *Nectria* spp.

(f) Hyperparasites are common. *Hansfordia ugandensis* (Hansf.) Hughes is frequently seen overgrowing various species of *Cercospora* and other fungi, while species of *Meliola* and *Asterina* are very often parasitized by species of *Helminthosporium* and *Eriomycopsis* and other hyphomycetes and ascomycetes. Some difficulty is often found in obtaining identifiable, unparasitized material of *Meliola* and *Asterina*.

It is therefore desirable that a collection should comprise an adequate sample of leaves or other material, so that all the fungi thereon will be well represented. It should also be remembered that plentiful material, even of common fungi, is always welcome for distribution to other herbaria as an exchange.

Collecting

Each collection should be clearly labelled with the name of the locality from which it was collected, the date of collection, and the name of the host plant or other matrix. Field notes, including a note as to whether or not the fungus appears to be abundant in the locality, are often helpful. It should be remembered that in some territories the names of towns or villages are often duplicated, or there may even be several villages bearing the same name situated within a fifty mile radius. It is therefore very desirable that the locality should be as clearly defined as possible ; e.g., by giving the name of the nearest big town in addition to that of the village or hill. (In Sierra Leone, though several village names are replicated there is not more than one village of that name in any one Chiefdom : hence the addition of the Chiefdom name adequately pinpoints the village.)

It is essential that each collection be given a separate serial number. Each collector may run his own serial numbers, or the collections may be given the serial accession numbers of a local herbarium. Each gathering, even from the same host plant on a different day, or from different host plants on the same day, should be given a separate serial number. The fungus is likely to be in quite a different state of development in each collection ; and though one gathering may show the one fungus

only, another may be overgrown or admixed with other fungi.

When more than one fungus is present, mixed on the same substratum, these are best indicated by the symbols (a), (b), etc., after the serial number. It is quite likely that a mycologist examining the material carefully at a later date may discover more different fungi than were at first observed.

As has already been said, many tropical fungus species are known only from one or a very few collections, and it is possible and, indeed, likely in some cases that several of these " species " may be only variants of one and the same species. The collector should therefore continue to collect the same sort of fungi from as many different matrices and localities as possible till he himself can come to some conclusion, after examination of the fungi in the laboratory, as to how many species are represented. Collecting should continue until the collector is sure that he is finding and being able to recognise the same species again and again. Such continued collecting of the same kind of fungus will also give valuable information about (a) relative abundance of each species, (b) preference for some particular substratum or habitat and (c) range of variation in the species. Some fungi may be relatively abundant one year but in succeeding years may be rare or apparently absent altogether. One must be on constant watch for the appearance of a new fungus especially on an economic host plant.

Drying the collections

Collections should be dried as rapidly as possible. Leaves are best dried between sheets of botanical drying paper or newspaper, changing the papers frequently, particularly during the first few days. Newspaper must be changed even more frequently at first than botanical drying paper. Wet sheets will dry rapidly if laid out in the sun, but during the wet season in the tropics it will probably be necessary to dry them by a fire. I have found a short length of corrugated iron, with a Primus stove or even a wood fire below one end, very useful on occasion for rapidly drying out papers. Do not leave specimens overnight between hot papers.

Rapid drying is essential, both to preserve the fungus as nearly as possible in the condition in which it was collected in the field and to prevent the growth of moulds such as *Aspergillus*. Certain hyphomycetes (e.g., some species of *Cercospora*) make abnormal growth in the humid conditions which obtain when kept even one day between damp papers : conidial

formation may cease and the conidiophores elongate, the material becoming valueless for identification purposes.

In rare cases it may be desirable to keep the material in a moist chamber for a short period (a few hours to a day or two) to induce spore production, but in the case of hyphomycetes this should be done with care and the material should be examined frequently and dried rapidly as soon as conidial production begins : a note should be made on the collection label, saying how long the material was kept in the moist chamber. With immature pyrenomycetes, it is probably best to label the material (branch, etc.) with a metal label and keep it outside under natural conditions till spores are produced.

I have found an electric heater, with a fan behind, very useful for drying specimens during the very wet months in Sierra Leone : even some fleshy fungi dried rapidly and well with this apparatus. The use of a desiccator may sometimes be of advantage, but the material usually becomes very brittle and must be allowed to absorb a little moisture after removal before being packeted and laid away.

Collecting agarics and other fleshy hymenomycetes in the tropics is a rather specialised field. Full details of colour (including changes of colour of the flesh when bruised), smell and taste (including a note as to whether the fungus is regarded locally as being edible or poisonous) should be given, and a coloured drawing of the fresh specimen is almost essential. A spore print should accompany the specimen. Most agarics can be dried but with more trouble than less fleshly fungi, and it is not usually possible to carry this out successfully away from headquarters. Fungi preserved in alcohol or formalin may be useful in special cases, to show natural size and shape, etc., but are inconvenient for detailed examination.

Polypores are easy to dry, but it is not always easy to obtain a spore print and the spores of many tropical species are so far unknown. From my experience, spore production in some species occurs for only a very short period : e.g., a common *Poria* in Sierra Leone apparently shed all its spores during one night only. Spore prints accompanying polypore specimens are therefore very desirable if obtainable.

Sending material to the C.M.I.

Send a reasonably large quantity of each collection when this is possible : twelve to twenty-four leaves of a foliicolous fungus is a good quantity. Make sure that the fungus which

you have seen and want identified is well represented on the material sent. If there are several fungi present, of which you want one or more especially named, send a slide of each or a drawing or description with the specimens. If a very early identification is wanted, a small representative part of the collection, showing clearly the fungus in question, may be sent in advance by air mail and the bulk of the collection can follow by surface mail: this is especially desirable when cultural studies are likely to be needed in the identification of the fungus.

The local herbarium

A local herbarium, containing parts of collections sent to the C.M.I., is invaluable for future reference. Microscope slide preparations may be kept with the specimens as is done in Herb. I.M.I. Wooden herbarium cupboards are recommended in the wet tropics, rather than metal ones, since moisture is more liable to condense at night in quantity on the metal. Care should be taken thoroughly to dry the specimens before they are laid away in the herbarium, and the herbarium sheets should be brought out and examined and re-dried regularly (particularly during a dry season).

As much ventilation as possible should be given, and specimens are less likely to become mouldy in herbarium cupboards which are constantly being opened and shut than in those kept permanently closed! The electric heater and fan mentioned above, directed on to open harbarium cupboards during the night in the wet season, is very helpful. In the wet tropics, preservation of herbarium material of some fungi will be found very difficult unless an air-conditioned room is available.

COLLECTING IN THE CLINIC

G. C. Ainsworth

Few mycological herbarium specimens originate from veterinary and medical clinics or pathological laboratories. Most morbid material (e.g. sputum, spinal fluid, pus and various exudates, and tissue samples) from which fungi are cultured is unsuitable for the herbarium, but stained smears or sections from such material if filed away with killed cultures of the isolates can provide useful data on the origin and the morphology of the parasitic state of the fungi involved.

One class of clinical specimens, however, makes ideal herbarium material. Hairs—human or animal, skin and nail scrapings, feathers, and horns infected by dermatophytes provide permanent records and continue to yield data of value long after the death of the pathogens. Similarly the hairs of black (*Piedraia hortai*) and white (*Trichosporon beigelii*) piedra and of trichonocardiosis axillaris (*Nocardia tenuis*) with their characteristic stromatic fungal or bacterial nodules resist ageing and remain of permanent value for reference.

Specimens from most superficial infections lose their pathogenicity within a few years but for herbarium purposes are easily rendered harmless by fumigation in Petri dishes between filter paper soaked in formalin or by fumigation with propylene oxide before being folded in packets of clean smooth paper, to which the normal herbarium label as described above, giving full details of origin, must be attached.

THE *INDEX OF FUNGI*

F. C. Deighton

An essential for the systematic mycologist is a complete list of all the names of fungi so far published. Saccardo's *Sylloge Fungorum* gave both names and diagnoses of genera, species, varieties and forms : the last volume (25) appeared in 1931 and the last three volumes included names of taxa published down to 1920. The *Sylloge* did not include all new combinations for old species.

When war broke out in 1939 five lists, compiled by Dr. F. Petrak of Vienna and published in *Just's Botanischer Jahresbericht*, were available in the United Kingdom : these attempted to list all new genera, species, varieties, and forms of fungi, and new combinations, with details of publication, which had appeared in literature during the years 1920–30. There was also Petrak's list for 1919, in *Just's Jber.*, **47** (1919), published in 1928, which included a few fungus names that had not appeared in Saccardo's *Sylloge*.

Dr. S. P. Wiltshire, then Director of the C.M.I., decided that the compilation of similar lists of new fungus names published from 1st January, 1940 ought to be undertaken by the C.M.I., and Dr. G. R. Bisby edited these lists (the first of which appeared, as *Review of Applied Mycology, Supplement* 1, in July 1940) till his retirement at the end of 1954. The *R.A.M.* supplements were renamed the *Index of Fungi*, starting with Vol. 1, Part 16 (1948), and it was decided to issue one volume of twenty parts for each ten-year period.

A brief account is given by Dr. Wiltshire in his Presidential Address to the British Mycological Society (*Trans. Brit. mycol. Soc.*, **26** : 2, 1944). It was then hoped that the gap between 1930 and 1940 would be filled at some future date.

Petrak's Lists

In 1946, two further lists by Petrak, also published in *Just's Jber.*, became available, covering the years 1931 and 1932–35. Dr. Petrak, who had made records of fungus names published down to 1938, agreed to complete his list to the end of 1939, which was published by the C.M.I. in 1959. Since *Just's Botanischer Jahresbericht* was no longer being issued and its stocks had been nearly all destroyed, permission was obtained for the C.M.I. to reprint Petrak's earlier lists numbered

as follows : 1 (1920) ; 2 (1921) ; 3 (1922–1928) ; 4 (1929) ; 5 (1930) ; 6 (1931) ; 7 (1932–1935) ; 8 (1936–1939). A cumulative index to Petrak's lists, Part 1 (generic names and specific epithets) and Part 2 (host plants), was published in 1956 (Part 1) and 1957 (Part 2) by the C.M.I.

Dr. Wiltshire, in his preface to *Petrak's List* 8, had in view the prospect that a complete index of the published names of fungi would ultimately be available to mycologists. During the past three years, a supplement to *Petrak's Lists* (1920–39) has been in preparation and it is hoped will be published in 1961. As was only to be expected, a number of new fungus names were omitted from *Petrak's Lists* because the journals or books in which they were published were not available to Dr. Petrak at the time. The supplementary list to date includes about 4,000 entries.

Saccardo's *Sylloge* did not attempt to give the numerous combinations proposed for old species, and ignored many genera proposed before 1920 : several new fungus species described, particularly about 1917–19, were not included in the *Sylloge*. A tentative start has been made, in the first place for the benefit of the mycologists at the C.M.I., to card-index such omissions from the *Sylloge*, but with no intention or prospect of the compilation (still less the publication) of anything like a complete list in the near future.

As a result of the increased number of workers in systematic mycology, the number of entries in the *Index of Fungi* has increased from just under 9,000 in Vol. 1 (1940–49) to about 23,500 in Vol. 2 (1950–59). Probably between a third and a half of the entries are new combinations.

Preparation

Periodicals, separates, and books received in the C.M.I. in which new fungus names appear are scrutinized by a herbarium assistant and the details of each new name are entered on a card. A card is also prepared for the specific epithet (with the generic name following) and another for the host plant or animal (under its family name) where applicable. The cards are then checked and edited by a Mycologist, and filed.

From the cards accumulated during that period the next issue of the *Index of Fungi* is prepared at the end of each half year. When the page proof of the *Index* has been checked, the page reference is entered on each card and the cards are then incorporated in the main file for the ten-year volume period.

Thus at least six to twelve months must elapse between the receipt of any publication and the issue of the part of the *Index* in which any new fungus name is included.

At the end of each ten-year volume, a cumulative fungus and host index is prepared for publication.

A card index record is kept of all periodicals and books from which entries in the *Index* have been abstracted, and a microfilm is made of all papers in which new fungus names appear in any periodical not filed by the C.M.I. References are frequently seen to new fungus names published in journals which are not received regularly at the C.M.I. Such journals are borrowed when possible from other libraries, but there may be considerable difficulty and delay in obtaining certain of them. particularly if they are not regularly taken by any library in the U.K. Very valuable assistance has been given by Dr. J. A. Stevenson and his staff (particularly Dr. Edith Cash till her retirement in 1959) at the United States Department of Agriculture, Agricultural Research Service, Beltsville, Maryland, who have supplied regular lists of periodicals which they have scrutinized for new fungus names, and have also indicated recently published homonyms which are only too easily overlooked in the preparation of the *Index*.

In the preparation of the *Index of Fungi*, the rules and recommendations of the *International Code of Botanical Nomenclature* are followed as far as practicable. Corrections to the spelling of specific epithets (which are sometimes inadvertently published in the wrong gender or in an incorrect genitive) are made when necessary in accordance with Chapter VI (Orthography) of the latest (1956) edition of the *Code*. This also makes the specific epithet index to each volume of the *Index* easier for reference than if the original orthographic errors were preserved, and indicates homonyms (or probable homonyms) which would otherwise be less obvious.

Note is taken of two important requirements by the *Code* for valid publication of a fungus name: (a) on or after 1st January, 1935, a Latin diagnosis is obligatory [Art. 34] and (b) a new transfer or combination published on or after 1st January, 1953 is not validly published unless the basonym is clearly indicated with a full reference to its author and original publication [Art. 32]. Since it would be inconvenient to systematic mycologists everywhere to omit from the *Index* all names not validly published, those published without a Latin diagnosis have

always been prefixed by an asterisk (*) : should they be validated at a later date by the same or another author, the citation of the valid publication of the name is given in the *Index*, with a back reference to the original invalid publication. Starting with Vol. 2, Part 16, issued in 1958, a dagger (†) has been placed before a new combination which does not comply with the provisions of Art. 32. It will be noted that of the new combinations published on or after 1st January, 1953 and listed in Vol. 2, Parts 7—15, some may not have complied with the provisions of Art. 32, but have not been so marked. A look-out is kept for the later valid publication of such new combinations, which is frequently made more by inadvertence than intent by another author, and such valid publication is noted by another entry in the *Index*, with a back reference to the original invalid publication.

Homonyms are frequently not discovered for some time, and this often necessitates another entry in a later Part of the *Index*. Similarly, supposedly new combinations proposed which, it is discovered, have already been made by an earlier author are noted with a suitable comment.

Art. 35 of the 1956 *Code* states that publication on or after 1st January, 1958 of the name of a new taxon of the rank of Order or below is valid only when the nomenclatural type is indicated. An attempt was made at the beginning of 1958 to add a remark, where applicable, to the effect that no type had been indicated, but it was decided that this was impracticable and the following note was inserted at the beginning of Vol. 2, Parts 17 and 18 (issued in 1958) of the *Index* : " Though in some cases (e.g., where more than one collection is cited none of which is indicated in the text as type) it seems clear that the intentions of Art. 35 have not been complied with, in other cases it has proved impracticable to come to any confident decision. In this *Index*, accordingly, apparent failure to fulfil the requirements of Art. 35 are not noted." Art. 35 or the 1956 *Code* needs clarification and rewording before it can be confidently applied by the ordinary worker to fungus nomenclature.

The Index of Fungi and Herb. I.M.I.

Further routine work undertaken by the herbarium assistant in charge of the *Index* is to note type and other collections cited in publications as having been deposited in Herb. I.M.I., to enter such details in the herbarium accession books and in the index of specific epithets, of which a card is

filed for every fungus represented in Herb. I.M.I. : such new names and combinations in the herbarium accession books, are brought to the attention of the Mycologist interested in that particular fungus group, who may wish to redispose the fungus accordingly in the herbarium, or merely to have the new name recorded on the herbarium specific epithet card for future reference.

THE *BIBLIOGRAPHY OF SYSTEMATIC MYCOLOGY*

GRACE M. WATERHOUSE

Just as a rational taxonomic study of pathogenic or economically important fungi requires a consideration of related saprophytic forms, so it is necessary to supplement a survey of the literature on applied mycology with one of taxonomic literature in general.

From the first, comparatively little of the literature on purely systematic mycology was noticed in the *Review of Applied Mycology ;* in general, only monographs containing important plant pathogens or papers containing lists of such pathogens were abstracted. The cessation of the *Thesaurus litteraturae mycologicae et lichenologicae* by G. Lindau and P. Sydow in 1917 created a lacuna after 1910 in the study of the systematic mycology, and the absence of a comprehensive compilation of mycological taxonomic literature has become increasingly felt over the years. True, *Biological Abstracts* to some extent provided the information, but here it was sometimes scattered among different sections, or even volumes, of a work of increasing size and cost, not easily accessible to many mycologists.

In 1943, therefore, work was started on a new publication, the *Bibliography of Systematic Mycology*, in which was gathered the titles of all papers of interest to the mycologist (whether abstracted for *R.A.M.* or not). Thus, it listed not only publications purely systematic in nature, but gave references to general papers on mycology and nomenclature, obituary notices, and lists of fungi and culture collections. The first number (*Mimeogr. Publ.* 3, now out of print), covering 1943 to 1946, appeared in 1947, and since then the publication has appeared annually, except on two occasions when two years were run together (1950–51, 1953–54). Its usefulness may be gauged by the number of entries, which increased from a total of 640 for the four years 1943–46 to 900 for the year 1958. Meanwhile, a

continuation of the *Thesaurus* has been completed for the years 1911–1930 (three volumes) by R. Ciferri (1957–59).

When the idea of the *Bibliography* was born there was a fond hope that the publication might be the precursor of a *Review of Systematic Mycology*, with abstracts of the publications instead of mere titles. Is it too much to hope that one day this might be so? Meanwhile our abstractors continue to inscribe on cards the particulars of publications we encounter, and our photo-offset department brings to life this publication at the very reasonable price of 7*s.* 6*d.* (in 1959). Taken in conjunction with the *Index of Fungi* it gives the embryo mycologist all the current preliminary information needed when starting out on any mycological project.

THE HERBARIUM AND *THE REVIEW OF APPLIED MYCOLOGY*

E. B. Martyn

The *Review of Applied Mycology* (RAM to the C.M.I. staff), vol. 1 of which was published in 1922, is essentially an abstracting journal for plant pathologists, but as its name implies, applied mycology was at one time synonymous with plant pathology, a subject now requiring a quite extensive knowledge of chemistry and at least some acquaintance with physics. The first plant pathologists appointed were designated mycologists, for in the first approach to the study of new plant diseases the fungi found in association were generally held to be responsible, often to the exclusion of other possible causes. But despite the wide field of plant diseases now covered by those of virus origin and the known parts played by soil and environment in the growth of plants the diseases directly attributable to bacterial or fungus pathogens are of paramount importance, and the identification and recognition of these organisms is a pre-requisite to their ultimate eradication or control. In the index to the 1958 volume of *R.A.M.* there are references to more than 1,200 pathogenic fungi and some 650 host plants.

The impact of mycology

A sound training in the plant sciences, with especial attention to botany, is, or should be, a primary necessity for a plant pathologist, particularly if he is to work in an area where new diseases and pathogens are often to be found and where the problems raised by new plant introductions commonly occur ; a state of affairs still prevalent in many parts of the Commonwealth. A knowledge of the fungus flora of an area and of the indigenous host plants of the parasites is a valuable background to a proper knowledge of the pathogens, both known and potential, of the economic plants grown and of possible alternative hosts.

Reliable records of the occurrence and distribution of all pathogens on economic plants also are essential, including pathogens of little apparent consequence which may assume greater importance as new host varieties are introduced or as they themselves give rise to strains of greater pathogenicity. It should, therefore, be the object of every plant pathologist to initiate or maintain a mycological herbarium for his area with

collections of suitable material, built up as circumstances permit, carrying the fungus in a readily recognizable state, with the host correctly named, and the date and locality of the collection recorded. Such records yield vital information as to the distribution, extent, and seasonal appearance of the crop plant diseases in the territory, and provide the foundation for the subsequent publication of lists of diseases, which are of great value to plant pathologists and mycologists throughout the world.

Nomenclature

In the formation of such collections and lists of fungi from various parts of the Commonwealth the Herb. I.M.I. has played an important part, both in naming material (often from specimens that are far from ideal !) and in checking nomenclature. These lists generally appear in the series *Mycological Papers* issued by the C.M.I., or are published by the Commonwealth territory concerned after scrutiny by the Institute. Full assistance can only be given to plant pathologists if they send regularly to the Institute typical sets of specimens in good sporing condition, so that the mycological staff have ample opportunity to compare these specimens with authentically named material in the herbarium. A little reflection will make it clear that by doing this plant pathologists and mycologists can be mutually beneficial to each other. Papers on systematic mycology are not abstracted in *R.A.M.* unless the fungi are of economic importance. Other taxonomic literature is listed annually by the Institute in its publication *The Bibliography of Systematic Mycology*.

Systematic Mycology

The Herbarium is generally the final arbiter on questions of nomenclature in all publications of the C.M.I., including the *Distribution Maps of Plant Diseases*. The attitude of the Editor is advisedly conservative in order to avoid the pitfall of constant name changes in the annual indexes. The crucial question is asked " Will the name be accepted in fifteen year's time ? " or, put another way, " Will the name survive three international botanical congresses ? " A name taken up by the Herbarium but not yet widely accepted, or liable to early change, is rejected in favour of an older synonym of long usage if there is any doubt as to the validity of the new name. The Herbarium records also form one of the most reliable sources of information for the C.M.I. maps of plant disease distribution,

since a named specimen of an organism from an exactly known locality is indisputable evidence of its occurrence, and preferable to less authentic references on which the maps must sometimes be based.

THE *REVIEW OF MEDICAL AND VETERINARY MYCOLOGY* AND THE HERBARIUM

G. C. Ainsworth

To the average medical or veterinary mycologist a herbarium is an irrelevancy. This attitude is largely the result of a century's divorce of studies on fungi pathogenic for man and higher animals from investigations on plant pathogenic fungi and the stream of general mycological research. During the nineteenth century medical and veterinary men did their own mycology and thereby made notable contributions to the knowledge of fungi. For example, up to the publication of *Les Teignes* in 1910 no group of fungi had received a more comprehensive treatment than did the ringworm fungi in that classic monograph by the French dermatologist Sabouraud, and there have been few comparable monographs since.

During the first quarter of the twentieth century the increasing complexities of both medicine and mycology led to an impasse. Non-medical mycologists regarded " medical fungi " as something apart and medical and veterinary men foundered on the taxonomic rocks. As a result the number of names increased vastly (the thirty or so species of dermatophytes now recognized having been proposed as some three hundred species and given a thousand names) and the standard of identification fell so low that even clinical results became meaningless.

All this has changed since the early nineteen thirties when, first in the United States and subsequently elsewhere, trained mycologists were appointed to work with medical and veterinary clinicians and pathologists. The best texts and monographs on medical mycology are now a model which plant pathologists might emulate.

Perhaps the most important result of the work of mycologists in the veterinary and medical fields is the realization that " medical fungi " are not a class apart. Many, if not most, are only incidentally pathogenic and are widespread as saprophytes both on and in man and animals and on a variety of other substrata, particularly soil : it seems likely that some ringworm

fungi are what Garrett would describe as " soil inhabitants." They are readily isolated, but there still seems to be no record of a non-medical student of soil fungi having recognized a dermatophyte among his isolates. Neither have such investigators recognized *Histoplasma capsulatum* or *Coccidioides immitis* which appear to be regularly present in soils over wide areas of North America and elsewhere. This does not mean that all " medical fungi " are easy to classify ; it does mean that their stable classification depends on relating them to " non-medical " forms.

All this was in essence realized by Dr. E. J. Butler, who in the *Transactions of the British Mycological Society* (7 : 168—172, 1921) stated that the objects of the newly formed Imperial Bureau of Mycology envisaged the inclusion of fungi of medical importance within the field of activities of the future Institute. For a number of years papers on the more mycological aspects of human and animal mycoses were noticed in the *Review of Applied Mycology*, but it was not until the recommendations of the Hankey Committee (see p.11) were implemented that the of literature medical and veterinary mycology began to receive adequate attention by the half-yearly issue from 1943 of the *Annotated Bibliography of Medical Mycology* : later the *Review of Medical and Veterinary Mycology* and from 1958 a quarterly journal.

These developments were not reflected in the Herbarium, but now an effort is being made to strengthen this side of Herb. I.M.I. Representative killed specimens of fungi pathogenic for higher animals are being assembled and integrated with the Herbarium by being indexed in a " host book " devoted to man and animals. One result of this will be that a non-veterinary mycologist looking into the *Aspergillus fumigatus* folder will find in addition to the conventional specimens described above slides of *A. fumigatus* looking very unlike its normal self in penguin lungs, while a veterinary mycologist looking for dermatophytes will find them disposed with related non-pathogenic imperfect and perfect fungi. This situation should encourage the proposal of fewer but more generally acceptable new taxa, and lead to the better integration of taxonomic mycology in general and a standard code of nomenclature for both the *Review of Medical and Veterinary Mycology* and the *Review of Applied Mycology* based on the technical advice of Herb. I.M.I.

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R. R. Davies, M.Sc., Ph.D.—airspora
F. C. Deighton, O.B.E., M.A., F.L.S.—Uredinales ; *Cercospora ;* edits *Index of Fungi*
J. J. Elphick, B.Sc.—Mucorales ; *Sporotrichum*
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Mrs. P. Scragg—Multilith operator.

Porter : J. Crawford

LIST OF PUBLICATIONS

Review of Applied Mycology

Consisting of abstracts or reviews of current world literature on applied mycology and plant pathology. First issued 1922.

Annual subscription, vol. 39, 1960	($9.80)	70*s.* 0*d.*
12 monthly parts, with title-page and index.		
Single parts	($0.85)	6*s.* 0*d.*
Title-page and index	($2.00)	14*s.* 0*d.*
Back volumes if available, *postage extra*	($11.00)	80*s.* 0*d.*
Single parts	($1.00)	7*s.* 0*d.*

Commonwealth Phytopathological News

A quarterly giving news and views of current phytopathological matters in the Commonwealth.

Annual subscription 5*s.* 0*d.* Single numbers 1*s.* 6*d.* each. The Journal is despatched with the Review of Applied Mycology for January, April, July, and October.

Distribution Maps of Plant Diseases

24 maps per annum including Revisions. Subscription price	($1.20)	7*s.* 6*d.*
24 copies or more 6*d.* per copy, odd numbers 9*d.* per copy. 370 maps issued to January, 1960.		
Loose leaf binding cases	($3.20)	21*s.* 0*d.*

Review of Medical and Veterinary Mycology (formerly **An Annotated Bibliography of Medical Mycology**)

Annual subscription (4 parts, issued March, June, September, December)	($4.20)	30*s.* 0*d.*
Volume I. 1943–52 (12 parts and index; 2,548 abstracts)	($21.00)	150*s.* 0*d.*
Volume II. 1953–57 (10 parts; 2,464 abstracts)	($17.50)	125*s.* 0*d.*
Back parts, as available, are sold separately :		
Vol. 1, 1–8 each	($1.40)	10*s.* 0*d.*
Vol. 1, 9–12 ,,	($1.75)	12*s.* 6*d.*
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